

Voltage Regulator Data Book

1983

Switching, Series Pass,
Shunt, Precision



TEXAS
INSTRUMENTS

General Information

Alphanumeric Index
Selection Guide
Alternate Source Index
Glossary

1

Descriptive Information

2

Appendix

Ordering Instructions
Mechanical Data

3

Voltage Regulator Data Book

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INSTRUMENTS

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Texas Instruments
Dallas, Texas 75243

VOLTAGE REGULATOR DATA BOOK

1983

Voltage regulation is a basic function in the majority of today's electronic systems. In this data book, Texas Instruments is pleased to present important technical information on a broad line of voltage regulator and voltage controller circuits that will assist the designer in selecting components for the complete power system.

This data book includes series pass regulators (both fixed and adjustable), shunt regulators, switching voltage controllers (fixed on-time variable frequency, PWM, single-ended, and dual-ended), DC-to-DC converters, over voltage and under voltage protection circuits.

A functional index, selection guide and alternate source index are included to provide the designer with rapid access to the desired technical information.

While this data book offers design data and specifications only for voltage regulators and voltage regulator-related products, complete technical data on any Texas Instruments semiconductor component is available from your nearest TI field sales office or local TI distributor.

General Information

Alphanumeric Index

Selection Guide

Alternate Source Index

Glossary

1

General Information
Administrative
Financial
Academic
Student Services
Faculty Services
Community Relations
Other

ALPHANUMERIC INDEX

DEVICE TYPE	PAGE	DEVICE TYPE	PAGE	DEVICE TYPE	PAGE
LM217	2-3	TL497AI	2-105	uA78L08AC	2-167
LM237	2-9	TL497AM	2-105	uA78L08C	2-167
LM317	2-3	TL498	2-109	uA78L09AC	2-167
LM320-3	2-13	TL580C	2-111	uA78L09C	2-167
LM320-12	2-13	TL593C	2-113	uA78L10AC	2-167
LM320-15	2-13	TL593I	2-113	uA78L10C	2-167
LM323	2-19	TL593M	2-113	uA78L12AC	2-167
LM330	2-25	TL594C	2-113	uA78L12C	2-167
LM337	2-9	TL594I	2-113	uA78L15AC	2-167
LM340-5	2-31	TL594M	2-113	uA78L15C	2-167
LM-340-12	2-31	TL595C	2-113	uA78M05C	2-173
LM340-15	2-31	TL595I	2-113	uA78M05M	2-173
LM350	2-39	TL780-05C	2-123	uA78M06C	2-173
LM2930-5	2-45	TL780-12C	2-123	uA78M06M	2-173
LM2930-8	2-45	TL780-15C	2-123	uA78M08C	2-173
MC3423	2-51	TL783AC	2-127	uA78M08M	2-173
MC34060	2-53	TL783C	2-129	uA78M10C	2-173
MC35060	2-53	TL1451C	2-137	uA78M10M	2-173
MC79L05AC	2-59	TL1525A	2-139	uA78M12C	2-173
MC79L05C	2-59	TL1527A	2-139	uA78M12M	2-173
MC79L12AC	2-59	TL2525A	2-139	uA78M15C	2-173
MC79L12C	2-59	TL2527A	2-139	uA78M15M	2-173
MC79L15AC	2-59	TL3525A	2-139	uA78M20C	2-173
MC79L15C	2-59	TL3527A	2-139	uA78M20M	2-173
RC4193C	2-63	TL7702	2-149	uA78M24C	2-173
RC4193I	2-63	TL7705	2-149	uA7905C	2-185
RC4193M	2-63	TL7712	2-149	uA7906C	2-185
SG1524	2-65	TL7715	2-149	uA7908C	2-185
SG2524	2-65	uA723C	2-153	uA7912C	2-185
SG3524	2-65	uA723M	2-153	uA7915C	2-185
TL317C	2-77	uA7805C	2-159	uA7918C	2-185
TL317M	2-77	uA7806C	2-159	uA7924C	2-185
TL430C	2-81	uA7808C	2-159	uA7952C	2-185
TL430I	2-81	uA7810C	2-159	uA79M05C	2-191
TL431C	2-85	uA7812C	2-159	uA79M05M	2-191
TL431I	2-85	uA7815C	2-159	uA79M06C	2-191
TL431M	2-85	uA7818C	2-159	uA79M06M	2-191
TL493C	2-93	uA7824C	2-159	uA79M08C	2-191
TL494C	2-93	uA7885C	2-159	uA79M08M	2-191
TL494I	2-93	uA78L02AC	2-167	uA79M12C	2-191
TL494M	2-93	uA78L02C	2-167	uA79M12M	2-191
TL495C	2-93	uA78L05AC	2-167	uA79M15C	2-191
TL495I	2-93	uA78L05C	2-167	uA79M15M	2-191
TL496C	2-101	uA78L06AC	2-167	uA79M20C	2-191
TL497AC	2-105	uA78L06C	2-167	uA79M24C	2-191

FIXED OUTPUT VOLTAGE REGULATORS

positive output regulators

DEVICE SERIES	OUTPUT VOLTAGE TOLERANCE	MINIMUM DIFFERENTIAL VOLTAGE	OUTPUT CURRENT RATING	AVAILABLE VOLTAGE SELECTIONS	PACKAGES
LM323	$\pm 10\%$ †	2.5 V	3 A	1 @ 5 V	KA
LM2930-0	$\pm 10\%$ †	0.6 V	150 mA	2 @ 5 V to 8 V	KC
LM330-0	$\pm 4\%$ ‡	0.6 V	150 mA	1 @ 5 V	KC
LM340-00	$\pm 4\%$ ‡	2.0 V	1.5 A	3 @ 5 V to 15 V	KC
TL780-00C	$\pm 1\%$ ‡	2.0 V	1.5 A	3 @ 5 V to 15 V	KC
uA7800C	$\pm 4\%$ ‡	2.0 V–3.0 V	1.5 A	9 @ 5 V to 24 V	KC
uA78L00AC	$\pm 5\%$ ‡	2.0 V	100 mA	8 @ 2.6 V to 15 V	LP
uA78L00C	$\pm 10\%$ ‡	2.0 V–2.5 V	100 mA	8 @ 2.6 V to 15 V	LP
uA78M00C*	$\pm 5\%$ ‡	2.0 V–3.0 V	500 mA	8 @ 5 V to 24 V	KC

† Overrange -40°C to 25°C ‡ @ 25°C

negative output regulators

DEVICE SERIES	OUTPUT VOLTAGE TOLERANCE	MINIMUM DIFFERENTIAL VOLTAGE	OUTPUT CURRENT RATING	AVAILABLE VOLTAGE SELECTIONS	PACKAGES
LM320-00	$\pm 4\%$	2.0 V	1.5 A	3 @ 5 V to 15 V	KC
MC79L00AC	$\pm 5\%$	1.7 V	100 mA	3 @ 5 V to 15 V	LP
MC79L00C	$\pm 10\%$	1.7 V	100 mA	3 @ 5 V to 15 V	LP
uA7900C	$\pm 5\%$	2.0 V–3.0 V	1.5 A	8 @ 5 V to 24 V	KC
uA79M00C*	$\pm 5\%$	2.0 V–3.0 V	1.5 A	7 @ 5 V to 24 V	KC

available output voltages for above regulator series

DEVICE SERIES	VOLTAGE SELECTIONS													
	2.6	5.0	5.2	6.0	6.2	8.0	8.5	9.0	10.0	12.0	15.0	18.0	20.0	24.0
LM2930-0		X				X								
LM320-00		X								X	X			
LM330-0		X												
LM340-00		X								X	X			
MC79L00AC		X								X	X			
MC79L00C		X								X	X			
TL780-00C		X								X	X			
uA7800C		X		X		X	X		X	X	X	X		X
uA7800AC	X	X			X	X		X	X	X	X			
uA78L00C	X	X			X	X		X	X	X	X			
uA78M00C*		X		X		X			X	X	X		X	X
uA7900C		X	X	X		X				X	X	X		X
uA7900C*		X		X		X				X	X		X	X

* Also available in military temperature range (M Suffix)

SELECTION GUIDE

VARIABLE OUTPUT VOLTAGE REGULATORS

positive output series regulators

DEVICE NUMBER	OUTPUT VOLTAGE		DIFFERENTIAL VOLTAGE MAX	OUTPUT CURRENT RATING	PACKAGES
	MIN	MAX			
LM217	1.2 V	37 V	$V_I - 1.2 \text{ V}$	1.5 A	KC
LM317	1.2 V	37 V	$V_I - 1.2 \text{ V}$	1.5 A	KC
LM350	1.2 V	33 V	$V_I - 1.2 \text{ V}$	3 A	KA, KC
TL317	1.2 V	32 V	$V_I - 1.2 \text{ V}$	100 mA	LP
TL783AC	5 V	200 V	200 V	700 mA	KC
TL783C	10 V	125 V	37 V	700 mA	KC
uA723C*	3 V	38 V	37 V	25 mA	J, N, U

negative output series regulators

DEVICE NUMBER	OUTPUT VOLTAGE		DIFFERENTIAL VOLTAGE MAX	OUTPUT CURRENT RATING	PACKAGES
	MIN	MAX			
LM237	1.2 V	37 V	$V_I + 1.2 \text{ V}$	1.5 A	KC
LM337	1.2 V	37 V	$V_I + 1.2 \text{ V}$	1.5 A	KC

positive shunt regulators

DEVICE NUMBER	SHUNT VOLTAGE		SHUNT CURRENT		TEMP COEFFICIENT MAX	PACKAGES
	MIN	MAX	MIN	MAX		
TL430C*	3 V	30 V	2 mA	100 mA	200 ppm/°C	JG, LP
TL431C*	3 V	30 V	0.5 mA	100 mA	100 ppm/°C	LP, P
TL431I**	2.55 V	36 V	1 mA	100 mA	100 ppm/°C	LP, P

*Also available in Military Temperature Range (M Suffix)

**I—Suffix for Industrial Temperature Range

PROTECTION CIRCUITS

undervoltage protection circuits

DEVICE NUMBER	TEMP RANGE	PACKAGES	FEATURES
TL7702 TL7705 TL7712 TL7715	0°C to 70°C	P	Power-up and voltage drop reset generator specifically for microcomputer control supervision. These devices operate over a wide supply voltage range (3 V to 18 V) and have externally adjustable pulse width to ensure system reset.

overvoltage protection circuit

DEVICE NUMBER	TEMP RANGE	PACKAGES	FEATURES
MC3423	0° to 70°C	JG, P	Separate outputs for "crowbar" and logic circuitry, programmable time delay, TTL-level activation isolated from voltage-sensing inputs.

SWITCHING VOLTAGE REGULATOR/CONTROLLERS

FEATURES	BASE DEVICE NUMBERS						
	MC35060 MC34060	RC1493	SG3524 SG2524 SG1524	SG3525A SG2524A SG1525A	TL493	TL494	TL495
General Features							
General Purpose	X	X	X	X	X	X	X
Special Purpose	—	—	—	—	—	—	—
Dual Independent PWM Control	—	—	—	—	—	—	—
Fixed On Time	—	—	—	—	—	—	—
Fixed Frequency PWM	X	X	X	X	X	X	X
Adjustable Frequency PWM	—	—	—	—	—	—	—
Low Bias Current Requirements	—	135 μ A	—	—	—	—	—
High Efficiency	—	80%	—	—	—	—	—
Expandable	X	—	X	X	X	X	X
Control Features							
On Chip Reference	X	X	X	X	X	X	X
Precision On Chip Reference	—	—	—	X	—	—	—
Dead Time Adjust	X	—	—	X	X	X	X
Current Sense Amplifier	—	—	—	—	1	—	—
Error Amplifier	2	—	2	1	1	2	2
Operates to 40 V	X	24 V	35 V	35 V	X	X	X
Operates above 40 V	—	—	—	—	—	—	X
Feed Forward Line Regulator	—	—	—	—	—	—	—
Protection Features							
On Chip Regulator	X	—	—	—	—	—	X
Internal Soft Start	—	—	X	X	—	—	—
Under Voltage Lockout	—	—	X	X	—	—	—
Inhibit Control	—	X	X	X	X	X	X
Double Pulse Protection	—	—	X	X	X	X	X
Output Features							
Single-ended Output	X	X	—	—	—	—	—
Double-ended Outputs	—	—	X	X	X	X	X
Totem-Pole Outputs	—	—	—	X	—	—	—
Parallelable Outputs	—	—	—	—	X	X	X
Adjustable Output (2.5 V to 24 V)	—	X	—	—	—	—	—
Output Current Capability (150 mA)	—	X	—	—	—	—	—
Isolated Power and Ground to Output	—	—	—	—	—	—	—
High Noise Immunity	—	—	—	—	—	—	—
External Output Trigger	—	—	—	—	—	—	X
Part Number Ordering Information							
Commercial Temp Range							
Plastic	MC34060N	RC1493CP	SG1524N	SG1525AN	TL493CN	TL494CN	TL495CN
Ceramic	MC34060J	RC1493CJG	SG1524J	SG1525AJ	TL493CJ	TL494CJ	TL495CJ
Industrial Temp Range							
Plastic		RC1493IP	SG2524N	SG2525AN		TL494IN	
Ceramic		RC1493IJG	SG2524J	SG2525AJ		TL494IJ	
Military Temp Range							
Ceramic	MC35060J	RC1493MJG	SG3524J	SG3525AJ	TL493MJ	TL494MJ	

1

SELECTION GUIDE

SWITCHING VOLTAGE REGULATOR/CONTROLLERS

FEATURES	BASE DEVICE NUMBERS						
	TL496	TL497A	TLC498	TL593	TL594	TL595	TL1451
General Features							
General Purpose	—	X	X	X	X	X	X
Special Purpose	9 V	—	—	—	—	—	—
Dual Independent PWM Control	—	—	X	—	—	—	—
Fixed On Time	X	X	—	—	—	—	—
Fixed Frequency PWM	—	—	X	X	X	X	X
Adjustable Frequency PWM	—	—	X	—	—	—	—
Low Bias Current Requirements	—	—	X	—	—	—	—
High Efficiency	—	—	—	—	—	—	—
Expandable	—	—	X	X	X	X	X
Control Features							
On Chip Reference	X	X	X	X	X	X	X
Precision On Chip Reference	—	—	X	X	X	X	—
Dead Time Adjust	X	—	X	X	X	X	X
Current Sense Amplifier	X	X	—	1	—	—	—
Error Amplifier	—	1	X	1	2	2	2
Operates to 40 V	—	—	20 V	X	X	X	X
Operates above 40 V	—	—	—	—	—	X	—
Feed Forward Line Regulator	—	—	X	—	—	—	—
Protection Features							
On Chip Regulator	X	—	X	—	—	X	—
Internal Soft Start	—	—	X	—	—	—	—
Under Voltage Lockout	—	—	X	X	X	X	—
Inhibit Control	—	X	X	X	X	X	—
Double Pulse Protection	—	—	X	X	X	X	—
Output Features							
Single-ended Output	X	X	—	—	—	—	2
Double-ended Outputs	—	—	X	X	X	X	—
Totem-pole Outputs	—	—	X	—	—	—	—
Parallelable Outputs	—	—	—	X	X	X	—
Adjustable Output (2.5 V to 24 V)	—	—	—	—	—	—	—
Output Current Capability (150 mA)	—	—	—	—	—	—	—
Isolated Power and Ground to Output	—	—	X	—	—	—	—
High Noise Immunity	—	—	X	—	—	—	—
External Output Trigger	—	—	—	—	—	X	—
Part Number Ordering Information							
Commercial Temp Range							
Plastic	TL496CP	TL497ACN	TLC498CN	TL593CN	TL594CN	TL596CN	TL1415CN
Ceramic	TL496CJ	TL497ACJ	TLC498CJ	TL593CJ	TL594CJ	TL595CJ	TL1415CJ
Industrial Temp Range							
Plastic		TL497AIN			TL594IN		
Ceramic		TL497AIJ			TL594IJ		
Military Temp Range							
Ceramic		TL497AMJ		TL593MJ	TL594MJ		

VOLTAGE REGULATOR ALTERNATE SOURCE INDEX

AMD **TI**
723C uA723C

Exar **TI**
XR2524 SG2524
XR3524 SG3524

Fairchild **TI**
μA78L02AC uA78L02AC
μA78L05AC uA78L05AC
μA78L09AC uA78L09AC
μA78L12AC uA78L12AC
μA78L15AC uA78L15AC
μA78L6.2AC uA78L06AC
μA78M05C uA78M05C
μA78M06C uA78M06C
μA78M08C uA78M08C
μA78M12C uA78M12C
μA78M15C uA78M15C
μA78M24C uA78M24C
μA79M05C uA79M05C
μA79M08C uA79M08C
μA79M12C uA79M12C
μA79M15C uA79M15C
μA217 LM217
μA317 LM317
μA431 TL431C
μA494 TL494C
μA723C uA723C
μA7805C uA7805C
μA7806C uA7806C
μA7808C uA7808C
μA7812C uA7812C
μA7815C uA7815C
μA7818C uA7818C
μA7824C uA7824C
μA7885C uA7885C
μA7905C uA7905C
μA7908C uA7908C
μA7912C uA7912C
μA7915C uA7915C

Fujitsu **TI**
MB3759 TL494C

ITT **TI**
TDD1605 uA78M05C
TDD1606 uA78M06C
TDD1608 uA78M08C
TDD1610 uA78M10C
TDD1612 uA78M12C
TDD1615 uA78M15C
TDD1624 uA78M24C

Lambda **TI**
LAS1505 uA7805C
LAS1506 uA7806C
LAS1508 uA7808C
LAS1510 uA7810C
LAS1512 uA7812C
LAS1515 uA7815C
LAS1518 uA7818C
LAS1524 uA7824C
LAS1805 uA7905C
LAS1806 uA7906C
LAS1808 uA7908C
LAS1812 uA7912C
LAS1815 uA7915C
LAS1818 uA7918C
LAS1824 uA7924C
LAS18052 uA7952C

Motorola **TI**
LM217 LM217
LM317L TL317
LM317 LM317
LM340-5 LM340-5
LM340-12 LM340-12
LM340-15 LM340-15
MC78L05AC uA78L05AC
MC78L05C uA78L05C
MC78L08AC uA78L08AC
MC78L08C uA78L08C
MC78L12AC uA78L12AC
MC78L12C uA78L12C
MC78L15AC uA78L15AC
MC78L15C uA78L15C
MC78M05C uA78M05C
MC78M06C uA78M06C
MC78M08C uA78M08C
MC78M12C uA78M12C
MC78M15C uA78M15C
MC78M20C uA78M20C
MC78M24C uA78M24C
MC79L05AC MC79L05AC
MC79L05C MC79L05C
MC79L12AC MC79L12AC
MC79L12C MC79L12C
MC79L15AC MC79L15AC
MC79L15C MC79L15C
MC1723C uA723C
MC3423 MC3423
MC7805C uA7805C
MC7806C uA7806C
MC7808C uA7808C
MC7812C uA7812C
MC7815C uA7815C

Motorola **TI**
MC7818C uA7818C
MC7824C uA7824C
MC7905C uA7905C
MC7906C uA7906C
MC7908C uA7908C
MC7912C uA7912C
MC7915C uA7915C
MC7918C uA7918C
MC7924C uA7924C
MC7905.2C uA7952C
MC34060 MC34060
MC35060 MC35060
TL431C TL431C
TL494C TL494C

National **TI**
LM78L05C uA78L05C
LM78L12C uA78L12C
LM78L15C uA78L15C
LM78M05 uA78M05C
LM78M12 uA78M12C
LM78M15 uA78M15C
LM79L05A LM79L05AC
LM79L05C MC79L05C
LM79L12A MC79L12AC
LM79L12C MC79L12C
LM79L15A MC79L15AC
LM79L15C MC79L15C
LM79M05 uA79M05C
LM79M12 uA79M12C
LM79M15 uA79M15C
LM217 LM217
LM237 LM237
LM317L TL317
LM317 LM317
LM320 LM320
LM323 LM323
LM330-5.0 LM330
LM337 LM337
LM340A-5.0 TL780-05C
LM340A-12 TL780-12C
LM340A-15 TL780-15C
LM340-5.0 LM340-5
LM340-12 LM340-12
LM340-15 LM340-15
LM350 LM350
LM723C uA723C
LM2524 SG2524
LM2930-5.0 LM2930-5
LM2930-8.0 LM2930-8
LM3524 SG3524
LM7805 uA7805C

VOLTAGE REGULATOR ALTERNATE SOURCE INDEX

National

LM7812	TI
LM7815	uA7812C
LM7905	uA7815C
LM7912	uA7905C
LM7915	uA7912C
	uA7915C

NEC

UPC78L05	TI
UPC78L08	uA78L05C
UPC78L12	uA78L08C
UPC78L15	uA78L12C
UPC78M05	uA78L15C
UPC78M08	uA78M05C
UPC78M12	uA78M08C
UPC78M15	uA78M12C
UPC494C	uA78M15C
UPC7805	TL494C
UPC7808	uA7805C
UPC7812	uA7808C
UPC7818	uA7812C
UPC7824	uA7818C
	uA7824C

RCA

CA723	TI
CA2524	uA723C
CA3524	SG2524
	SG3524

Raytheon

RC723	TI
RC4193	uA723C
	RC4193

Signetics

SG2524	TI
SG3524	SG2524
SG3525A	SG3524
SG3527A	SG3525A
uA723C	SG3527A
	uA723C

Silicon

General	TI
SG217	LM217
SG237	LM237
SG317	LM317
SG323	LM323
SG337	LM337
SG340-5	LM340-5
SG340-12	LM340-12
SG350	LM350
SG723C	uA723C
SG1525A	SG1525A
SG1527A	SG1527A
SG2524	SG2524
SG2525A	SG2525A

Silicon

General	TI
SG2527A	SG2527A
SG3423	MC3423
SG3524	SG3524
SG3525A	SG3525A
SG3527A	SG3527A
SG7805C	uA7805C
SG7806C	uA7806C
SG7808C	uA7808C
SG7812C	uA7812C
SG320-05T	uA79M05C
SG320-08T	uA79M08C
SG320-20T	uA79M20C
SG7815C	uA7815C
SG7818C	uA7818C
SG7805CT	uA78M05C
SG7806CT	uA78M06C
SG7808CT	uA78M08C
SG7812CT	uA78M12C
SG7815CT	uA78M15C
SG7820CT	uA78M20C
SG7824CT	uA78M24C
SG7824C	uA7824C
SG7905.2C	uA7952C
SG7905C	uA7905C
SG7908C	uA7908C
SG7912C	uA7912C
SG7915C	uA7915C
SG7918C	uA7918C

Toshiba

TA78L005A	TI
TA78L005	uA78L005A
TA78L008A	uA78L005C
TA78L008	uA78L08AC
TA78L009A	uA78L08C
TA78L009	uA78L09AC
TA78L010A	uA78L09C
TA78L010	uA78L10AC
TA78L012A	uA78L10C
TA78L012	uA78L12AC
TA78L015A	uA78L12C
TA78L015	uA78L15AC
TA7316	uA78L15C
	uA78L20C

Unitrode

UC217	TI
UC237	LM217
UC317	LM237
UC337	LM317
UC350	LM337
	LM350

Unitrode

UC2524	TI
UC3524	SG2524
UC3525A	SG3524
UC3527A	SG3525A
UC493AC	SG3527A
UC494AC	TL593C
UC495AC	TL594C
UC7805AC	TL595C
UC7805C	TL780-05C
7812AC	uA7805C
UC7812C	TL780-12C
UC7815AC	uA7812C
UC7815C	TL780-15C
UC7905C	uA7815C
UC7912C	uA7905C
UC7915C	uA7912C
	uA7915C

SERIES REGULATORS

Input Regulation

The change in output voltage, often expressed as a percentage of output voltage, for a change in input voltage from one level to another level.

NOTE: Sometimes this characteristic is normalized with respect to the input voltage change.

1

Ripple Rejection

The ratio of the peak-to-peak input ripple voltage to the peak-to-peak output ripple voltage.

NOTE: This is the reciprocal of ripple sensitivity.

Ripple Sensitivity

The ratio of the peak-to-peak output ripple voltage, sometimes expressed as a percentage of output voltage, to the peak-to-peak input ripple voltage.

NOTE: This is the reciprocal of ripple rejection.

Output Regulation

The change in output voltage, often expressed as a percentage of output voltage, for a change in load current from one level to another level.

Output Resistance

The output resistance under small-signal conditions.

Temperature Coefficient of Output Voltage (α_{VO})

The ratio of the change in output voltage, usually expressed as a percentage of output voltage, to the change in temperature. This is the average value for the total temperature change.

$$\alpha_{VO} = \pm \left[\frac{V_O \text{ at } T_2 - V_O \text{ at } T_1}{V_O \text{ at } 25^\circ\text{C}} \right] \left[\frac{100\%}{T_2 - T_1} \right]$$

Output Voltage Change with Temperature

The percentage change in the output voltage for a change in temperature. This is the net change over the total temperature range.

Output Voltage Long-Term Drift

The change in output voltage over a long period of time.

Output Noise Voltage

The rms value of the ac component of the output voltage, sometimes expressed as a percentage of the dc output voltage, with constant load and no input ripple.

Current-Limit Sense Voltage

The current-sense voltage at which current limiting occurs.

Current-Sense Voltage

The voltage that is a function of the load current and is normally used for control of the current-limiting circuitry.

Dropout Voltage

The low input-to-output differential voltage at which the circuit ceases to regulate against further reductions in input voltage.

GLOSSARY

VOLTAGE-REGULATOR TERMS AND DEFINITIONS

Feedback Sense Voltage

The voltage that is a function of the output voltage and is used for feedback control of the regulator.

Reference Voltage

The voltage that is compared with the feedback sense voltage to control the regulator.

Bias Current

The difference between input and output currents.

NOTE: This is sometimes referred to as quiescent current.

Standby Current

The input current drawn by the regulator with no output load and no reference voltage load.

Short-Circuit Output Current

The output current of the regulator with the output shorted to ground.

Peak Output Current

The maximum output current that can be obtained from the regulator due to limiting circuitry within the regulator.

Overvoltage Shutdown Voltage

The input voltage applied to a regulator having overvoltage shutdown protection that will cause the output voltage to go nearly to zero.

Junction Temperature, Virtual Junction Temperature

A temperature representing the temperature of the junction(s), field-effect transistor channel(s), or other internal point(s) of heat generation calculated on the basis of a simplified model of the thermal and electrical behavior of the semiconductor device.

SHUNT REGULATORS

NOTE: These terms and symbols are based on JEDEC and IEC standards for voltage regulator diodes.

Shunt Regulator

A device having a voltage-current characteristic similar to that of a voltage-regulator diode; normally biased to operate in a region of low differential resistance (corresponding to the breakdown region of a regulator diode) to develop across its terminals an essentially constant voltage throughout a specified current range.

Anode

The electrode to which the regulator current flows within the regulator when it is biased for regulation.

Cathode

The electrode from which the regulator current flows within the regulator when it is biased for regulation.

Reference Input Voltage (V_{ref}) (of an adjustable shunt regulator)

The voltage at the reference input terminal with respect to the anode terminal.

Temperature Coefficient of Reference Voltage (αV_{ref})

The ratio of the change in reference voltage to the change in temperature. This is the average value for the total temperature change.

To obtain a value in ppm/ $^{\circ}$ C:

$$\alpha V_{ref} = \left[\frac{V_{ref} \text{ at } T_2 - V_{ref} \text{ at } T_1}{V_{ref} \text{ at } 25^{\circ}\text{C}} \right] \left[\frac{10^6}{T_2 - T_1} \right]$$

Regulator Voltage (V_Z)

The dc voltage across the regulator when it is biased for regulation.

Regulator Current (I_Z)

The dc current through the regulator when it is biased for regulation.

Regulator Current near Lower Knee of Regulation Range (I_{ZK})

The regulator current near the lower limit of the region within which regulation occurs; this corresponds to the breakdown knee of a regulator diode.

Regulator Current at Maximum Limit of Regulation Range (I_{ZM})

The regulator current above which the differential resistance of the regulator significantly increases.

Differential Regulator Resistance (r_Z)

The quotient of a change in voltage across the regulator and the corresponding change in current through the regulator when it is biased for regulation.

Noise Voltage (V_{nz})

The rms value of the ac component of the voltage across the regulator with the regulator biased for regulation and with no input ripple.

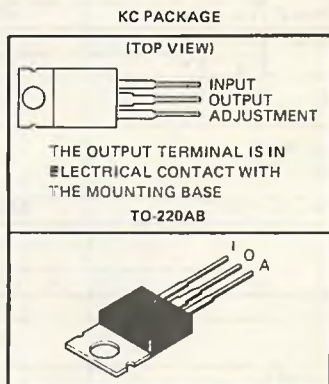
1

Descriptive Information

2

- Output Voltage Range Adjustable from 1.2 V to 37 V
- Guaranteed Output Current Capability of 1.5 A
- Input Regulation Typically 0.01% Per Input-Volt Change
- Output Regulation Typically 0.1%
- Peak Output Current Constant Over Temperature Range of Regulator
- Popular 3-Lead TO-220AB Package
- Ripple Rejection Typically 80 dB
- Direct Replacement for National LM217 and LM317

terminal assignments



description

The LM217, and LM317 are adjustable 3-terminal positive-voltage regulators capable of supplying 1.5 amperes over a differential voltage range of 3 volts to 40 volts. They are exceptionally easy to use and require only two external resistors to set the output voltage. Both input and output regulation are better than standard fixed regulators. The devices are packaged in a standard transistor package that is easily mounted and handled.

In addition to higher performance than fixed regulators, these regulators offer full overload protection available only in integrated circuits. Included on the chip are current limit, thermal overload protection, and safe-area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected. Normally, no capacitors are needed unless the device is situated far from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection, which is difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, these regulators are useful in a wide variety of other applications. The primary applications of each of these regulators is that of a programmable output regulator, but by connecting a fixed resistor between the adjustment terminal and the output terminal, each device can be used as a precision current regulator. Even though the regulator is floating and sees only the input-to-output differential voltage, use of these devices to regulate output voltages that would cause the maximum-rated differential voltage to be exceeded if the output became shorted to ground is not recommended. The TL783 or TL783A is recommended for output voltages exceeding 37 volts. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground, which programs the output to 1.2 volts where most loads draw little current.

The LM217 and LM317 are characterized for operation from -25°C to 150°C and from 0°C to 125°C , respectively.

TYPES LM217, LM317

3-TERMINAL ADJUSTABLE REGULATORS

electrical characteristics over recommended ranges of operating virtual junction temperature
(unless otherwise noted)

PARAMETER	TEST CONDITIONS [†]	LM217			LM317			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Input regulation (See Note 2)	$V_I - V_O = 3 \text{ V to } 40 \text{ V}$, $T_J = 25^\circ\text{C}$ See Note 3 $I_O = 10 \text{ mA to } 1.5 \text{ A}$	0.01	0.02		0.01	0.04		%/V
Ripple rejection	$V_O = 10 \text{ V}$, $V_O = 10 \text{ V}$, $f = 120 \text{ Hz}$ 10- μF capacitor between ADJ and ground		65			65		dB
		66	80		66	80		
Output regulation	$I_O = 10 \text{ mA to } 1.5 \text{ A}$, $V_O \leq 5 \text{ V}$		5	15		5	25	mV
	$T_J = 25^\circ\text{C}$, See Note 3 $V_O > 5 \text{ V}$		0.1	0.3		0.1	0.5	%
	$I_O = 10 \text{ mA to } 1.5 \text{ A}$, $V_O \leq 5 \text{ V}$		20	50		20	70	mV
	See Note 3 $V_O > 5 \text{ V}$		0.3	1		0.3	1.5	%
Output voltage change with temperature	$T_J = \text{MIN to MAX}$		1			1		%
Output voltage long-term drift (see Note 4)	After 1000 h at $T_J = \text{MAX}$ and $V_I - V_O = 40 \text{ V}$		0.3	1		0.3	1	%
Output noise voltage	$f = 10 \text{ Hz to } 10 \text{ kHz}$, $T_J = 25^\circ\text{C}$		0.003			0.003		%
Minimum output current to maintain regulation	$V_I - V_O = 40 \text{ V}$		3.5	5		3.5	10	mA
Peak output current	$V_I - V_O \leq 15 \text{ V}$	1.5	2.2		1.5	2.2		A
	$V_I - V_O \leq 40 \text{ V}$		0.4			0.4		
Adjustment-terminal current			50	100		50	100	μA
Change in adjustment- terminal current	$V_I - V_O = 2.5 \text{ V to } 40 \text{ V}$, $I_O = 10 \text{ mA to } 1.5 \text{ A}$		0.2	5		0.2	5	μA
Reference voltage (output to ADJ)	$V_I - V_O = 3 \text{ V to } 40 \text{ V}$, $I_O = 10 \text{ mA to } 1.5 \text{ A}$, $P \leq 20 \text{ W}$	1.2	1.25	1.3	1.2	1.25	1.3	V

[†] Unless otherwise noted, these specifications apply for the following test conditions: $V_I - V_O = 5 \text{ V}$ and $I_O = 0.5 \text{ A}$. For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

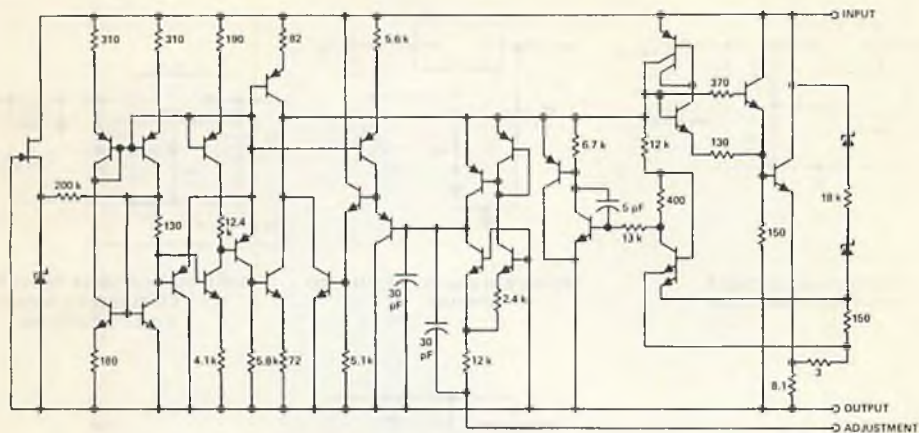
NOTES: 2. Input regulation is expressed here as the percentage change in output voltage per 1-volt change at the input.

3. Input regulation and output regulation are measured using pulse techniques ($t_{\text{pw}} \leq 10 \mu\text{s}$, duty cycle $\leq 5\%$) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.

4. Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPES LM217, LM317
3-TERMINAL ADJUSTABLE REGULATORS

schematic



All resistor values shown are nominal and in ohms.

absolute maximum ratings over operation temperature range (unless otherwise noted)

	LM217	LM317	UNIT
Input-to-output differential voltage, $V_I - V_O$	40	40	V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2000	2000	mW
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	20	20	W
Operating free-air, case, or virtual junction temperature range	-25 to 150	0 to 125	°C
Storage temperature range	-65 to 150	-65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260	260	°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Curves, Figures 15 and 16, page 104.

recommended operating conditions

	LM217		LM317		UNIT
	MIN	MAX	MIN	MAX	
Output current, I_O	5	1500	10	1500	mA
Operating virtual junction temperature, T_J	-25	150	0	125	°C

TYPES LM217, LM317 3-TERMINAL ADJUSTABLE REGULATORS

TYPICAL APPLICATION DATA

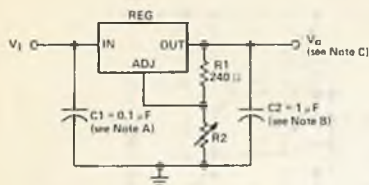


FIGURE 1—ADJUSTABLE VOLTAGE REGULATOR

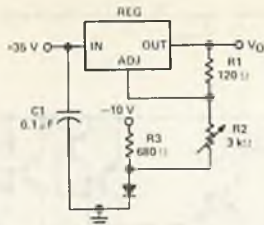
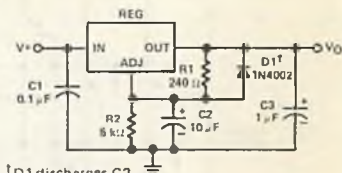


FIGURE 2—0-V to 30-V REGULATOR CIRCUIT



[†]D1 discharges C2 if output is shorted to ground.

FIGURE 3—ADJUSTABLE REGULATOR CIRCUIT WITH IMPROVED RIPPLE REJECTION

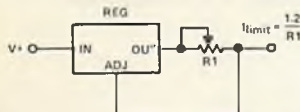


FIGURE 4—PRECISION CURRENT LIMITER CIRCUIT

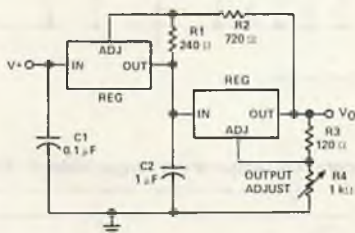


FIGURE 5—TRACKING PREREGULATOR CIRCUIT

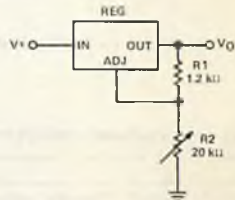
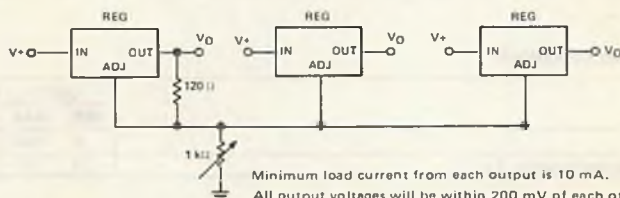


FIGURE 6—1.2 to 20-V REGULATOR CIRCUIT WITH MINIMUM PROGRAM CURRENT



Minimum load current from each output is 10 mA.
All output voltages will be within 200 mV of each other.

FIGURE 7—ADJUSTING MULTIPLE ON CARD REGULATORS WITH A SINGLE CONTROL

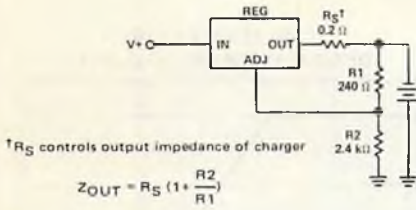
NOTES: A. Use of an input bypass capacitor is recommended if regulator is far from filter capacitors.

B. Use of an output capacitor improves transient response but is optional.

C. Output voltage is calculated from the equation: $V_O = V_{ref} \left(1 + \frac{R_2}{R_1} \right)$

V_{ref} equals the difference between the output and adjustment terminal voltages.

TYPICAL APPLICATIONS



The use of R_S allows low charging rates with a fully-charged battery.

FIGURE 8—BATTERY CHARGER CIRCUIT

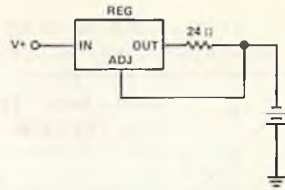


FIGURE 9—50-mA CONSTANT-CURRENT BATTERY CHARGER CIRCUIT

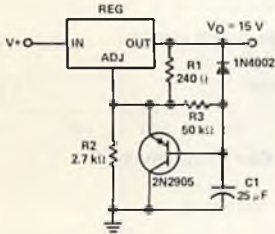


FIGURE 10—SLOW-TURN-ON 15-V REGULATOR CIRCUIT

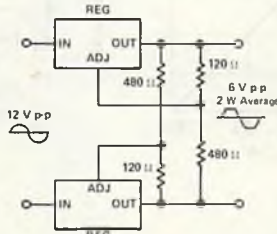
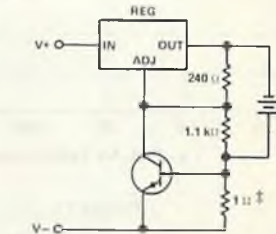


FIGURE 11—A-C VOLTAGE REGULATOR CIRCUIT



† This resistor sets peak current (0.6 A for 1 Ω).

FIGURE 12—CURRENT-LIMITED 5-V CHARGER

2

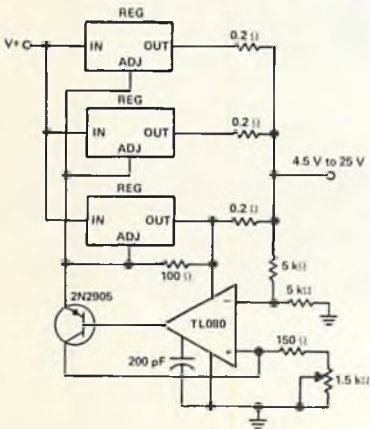
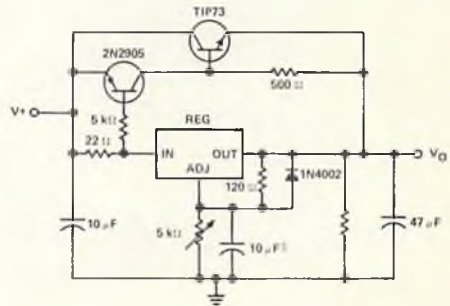


FIGURE 13—ADJUSTABLE 4-A REGULATOR



* Minimum load current is 30 mA.
† Optional capacitor improves ripple rejection

FIGURE 14—HIGH-CURRENT ADJUSTABLE REGULATOR

TYPES LM217, LM317

3-TERMINAL ADJUSTABLE REGULATORS

THERMAL INFORMATION

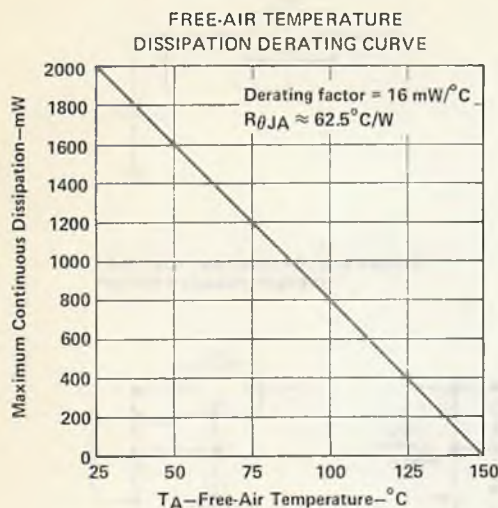


FIGURE 15

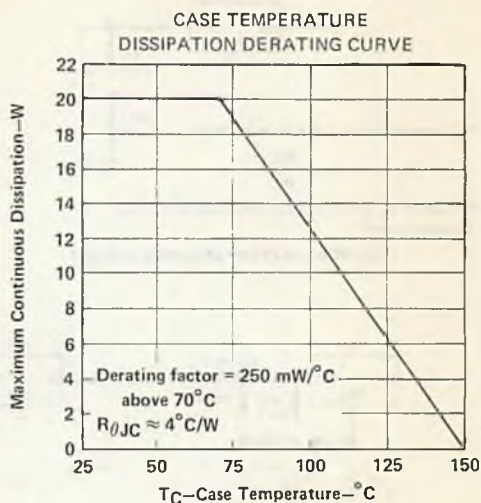
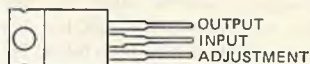


FIGURE 16

- Output Voltage Range Adjustable from -1.2 V to -37 V
- Guaranteed I_O Capability of 1.5 A
- Input Regulation Typically 0.01% per Input-Volt Change
- Output Regulation Typically 0.3%
- Peak Output Current Constant Over Temperature Range of Regulator
- Ripple Rejection Typically 77 dB
- Direct Replacement for National Semiconductor LM237, LM337

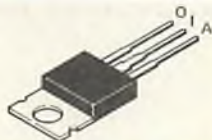
LM237, LM337 . . . KC PACKAGE

(TOP VIEW)



THE INPUT TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB

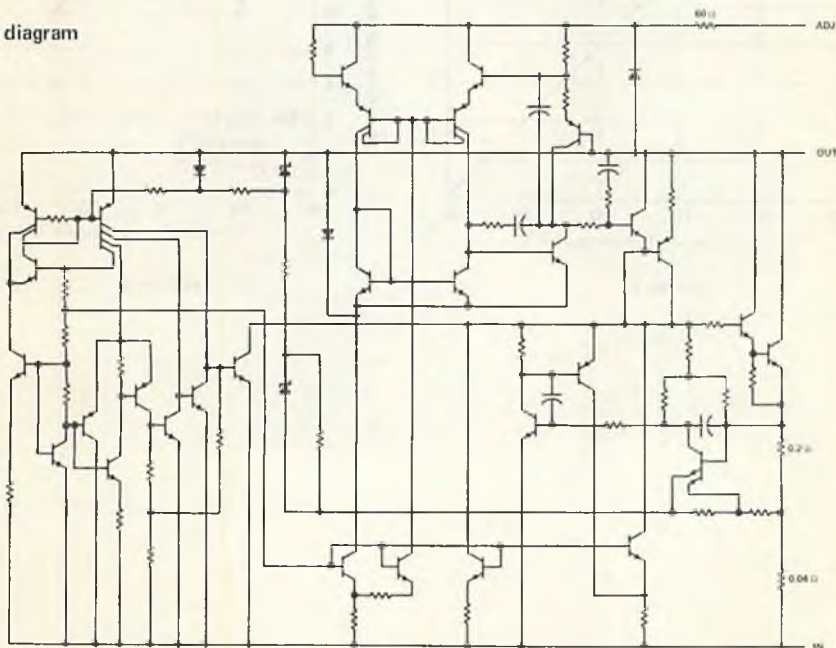


description

The LM237 and LM337 are adjustable 3-terminal negative-voltage regulators capable of supplying in excess of -1.5 A over an output voltage range of -1.2 V to -37 V . They are exceptionally easy to use, requiring only two external resistors to set the output voltage and one output capacitor for frequency compensation. The current design has been optimized for excellent regulation and low thermal transients. In addition the LM237 and LM337 feature internal current limiting, thermal shutdown, and safe-area compensation, making them virtually immune to blowout by overloads.

The LM237 and LM337 serve a wide variety of applications including local on-card regulation, programmable output voltage regulation, or precision current regulation. They are ideal complements to the LM217 and LM317 adjustable positive-voltage regulators.

schematic diagram



2

TYPES LM237, LM337
3-TERMINAL ADJUSTABLE REGULATORS

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input-to-output differential voltage, $V_I - V_O$	-40 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	20 W
Operating free-air, case, or virtual junction temperature range: LM237	-25°C to 150°C
LM337	0°C to 125°C
Storage temperature range	-65°C to 150°C
Lead temperature 1/16 inch from case for 10 seconds	260°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Curves, Figures 1 and 2.

2

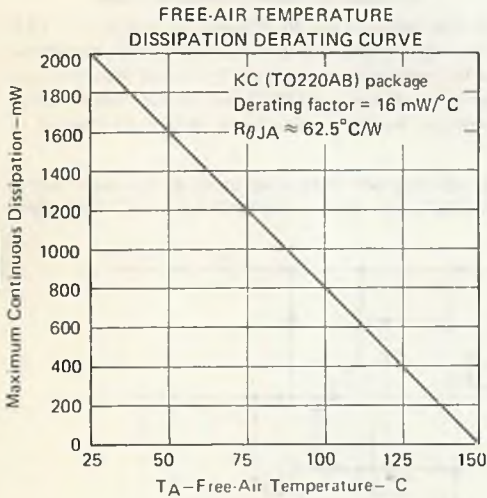


FIGURE 1

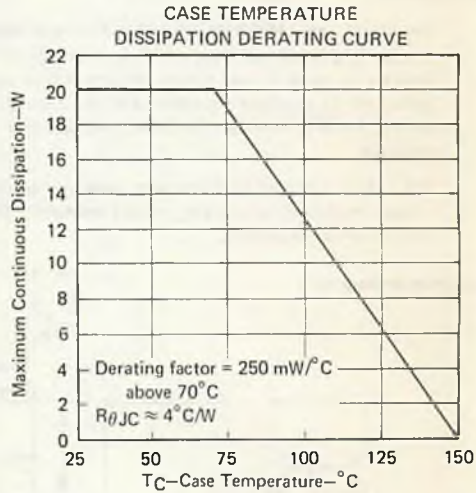


FIGURE 2

TYPES LM237, LM337

3-TERMINAL ADJUSTABLE REGULATORS

recommended operating conditions

		LM237		LM337		UNIT
		MIN	MAX	MIN	MAX	
Output current, I_O	$ V_I - V_O < 40 \text{ V}$, $P < 15 \text{ W}$	10	1500	10	1500	mA
	$ V_I - V_O < 10 \text{ V}$, $P < 15 \text{ W}$	6	1500	6	1500	
	Operating virtual junction temperature, T_J	-25	150	0	125	

electrical characteristics over recommended ranges of operating virtual junction temperature
(unless otherwise noted)

PARAMETER	TEST CONDITIONS†		LM237			LM337			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Input regulation‡	$V_I - V_O = -3 \text{ V to } -40 \text{ V}$, See Note 2	$T_J = 25^\circ \text{C}$ $T_J = \text{MIN to MAX}$	0.01	0.02		0.01	0.04		%/V
Ripple rejection	$V_O = -10 \text{ V}$, $f = 120 \text{ Hz}$		60			60			dB
	$V_O = -10 \text{ V}$, $C_{ADJ} = 10 \mu\text{F}$	$f = 120 \text{ Hz}$	66	77		66	77		
Output regulation	$I_O = 10 \text{ mA to } 1.5 \text{ A}$, $T_J = 25^\circ \text{C}$, See Note 2	$ V_O < 5 \text{ V}$ $ V_O > 5 \text{ V}$			25 0.5			50 1	mV %
	$I_O = 10 \text{ mA to } 1.5 \text{ A}$, See Note 2	$ V_O < 5 \text{ V}$ $ V_O > 5 \text{ V}$			50 1			70 1.5	mV %
Output voltage change with temperature	$T_J = \text{MIN to MAX}$		0.6			0.6			%
Output voltage long-term drift (see Note 3)	After 1000 h at $T_J = \text{MAX}$ and $V_I - V_O = -40 \text{ V}$		0.3	1		0.3	1		%
Output noise voltage	$f = 10 \text{ Hz to } 10 \text{ kHz}$, $T_J = 25^\circ \text{C}$		0.003			0.003			%
Minimum output current to maintain regulation	$ V_I - V_O < 40 \text{ V}$		2.5	5		2.5	10		mA
	$ V_I - V_O < 10 \text{ V}$		1.2	3		1.5	6		
Peak output current	$ V_I - V_O < 15 \text{ V}$		1.5	2.2		1.5	2.2		A
	$ V_I - V_O < 40 \text{ V}$, $T_J = 25^\circ \text{C}$		0.24	0.4		0.15	0.4		
Adjustment-terminal current			65	100		65	100		μA
Change in adjustment terminal current	$V_I - V_O = -2.5 \text{ V to } -40 \text{ V}$, $I_O = 10 \text{ mA to MAX}$, $T_J = 25^\circ \text{C}$		2	5		2	5		μA
Reference voltage (output to ADJ)	$V_I - V_O = -3 \text{ to } -40 \text{ V}$, $I_O = 10 \text{ mA to } 1.5 \text{ A}$, $P < \text{rated dissipation}$	$T_J = 25^\circ \text{C}$ $T_J = \text{MIN to MAX}$	-1.225	-1.250	-1.275	-1.213	-1.25	-1.287	V
			-1.2	-1.25	-1.3	-1.2	-1.25	-1.3	
Thermal regulation	Initial $T_J = 25^\circ \text{C}$, 10-ms pulse		0.002	0.02		0.003	0.04		%/W

† Unless otherwise noted, these specifications apply for the following test conditions $|V_I - V_O| = 5 \text{ V}$ and $I_O = 0.5 \text{ A}$. For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡ Input regulation is expressed here as the percentage change in output voltage per 1 volt change at the input.

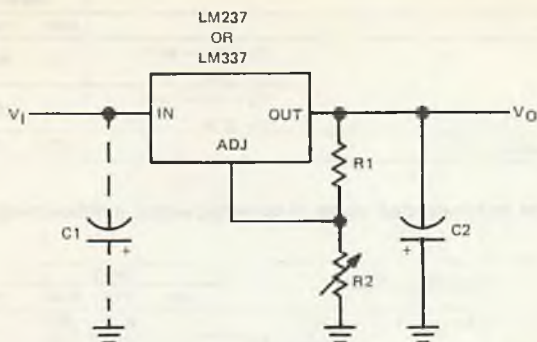
NOTES: 2. Input regulation and output regulation are measured using pulse techniques ($t_w < 10 \mu\text{s}$, duty cycle $< 5\%$) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.

3. Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPES LM237, LM337

3-TERMINAL ADJUSTABLE REGULATORS

TYPICAL APPLICATION DATA



R1 is typically 120 Ω .

$$R2 = R1 \left(\frac{-V_O}{-1.25} - 1 \right) \text{ where } V_O \text{ is the output in volts.}$$

C1 is a 1- μ F solid tantalum required only if the regulator is more than 10 cm (4 in.) from the power supply filter capacitor.

C2 is a 1- μ F solid tantalum or 10- μ F aluminum electrolytic required for stability.

FIGURE 3 — ADJUSTABLE NEGATIVE-VOLTAGE REGULATOR

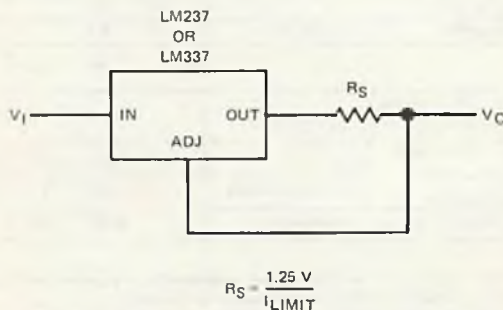


FIGURE 4 — CURRENT-LIMITING CIRCUIT

- 3-Terminal Regulators
- Internal Thermal Overload Protection
- Internal Short-Circuit Current Limiting
- Easily Adjustable to Higher Output Voltage
- Interchangeable with National Semiconductor LM320 Series

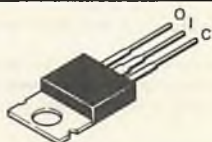
KC PACKAGE

(TOP VIEW)



THE INPUT TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



NOMINAL OUTPUT VOLTAGE	MAXIMUM OUTPUT CURRENT	REGULATOR
-5 V	1.5 A	LM320-5
-12 V	1 A	LM320-12
-15 V	1A	LM320-15

description

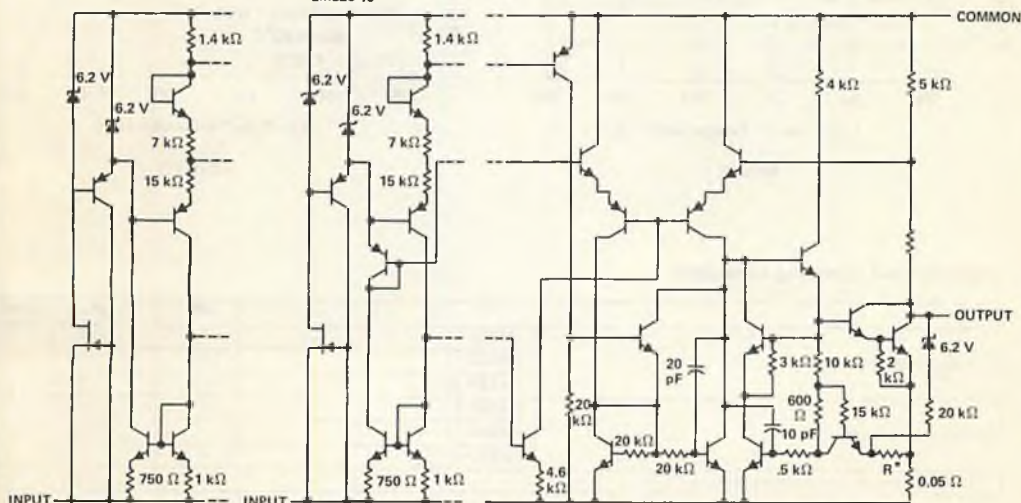
The LM320 series of three-terminal, fixed-negative-voltage monolithic integrated circuit voltage regulators are designed to provide a fixed output voltage of -5 volts, -12 volts, and -15 volts with up to 1.5 amperes of output current. Each is designed for a wide range of applications which includes on-card regulation for elimination of noise and distribution problems associated with single-point regulation.

The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. The LM320, when used as a fixed-voltage regulator, needs only one external component: a compensation capacitor at the output terminal. In addition, these devices can be used with external components to obtain adjustable output voltages and currents or as the power-pass element in precision regulators.

schematic diagram

LM320-5

LM320-12
LM320-15



For LM320-5, $R^* = 50 \Omega$. For LM320-12 and LM320-15, $R^* = 150 \Omega$
All component values are nominal.

TYPE SERIES LM320

3-TERMINAL NEGATIVE-VOLTAGE REGULATORS

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input voltage: LM320-5	-25 V
LM320-12	-35 V
LM320-15	-35 V
Input-output voltage differential	25 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	15 W
Operating free-air, case, or virtual junction temperature range	-55°C to 150°C
Storage temperature range	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation.

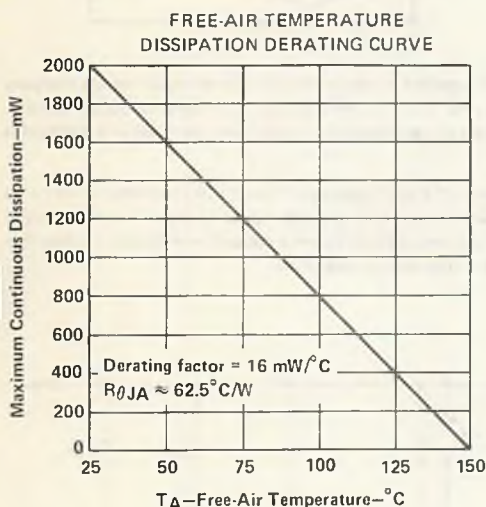


FIGURE 1

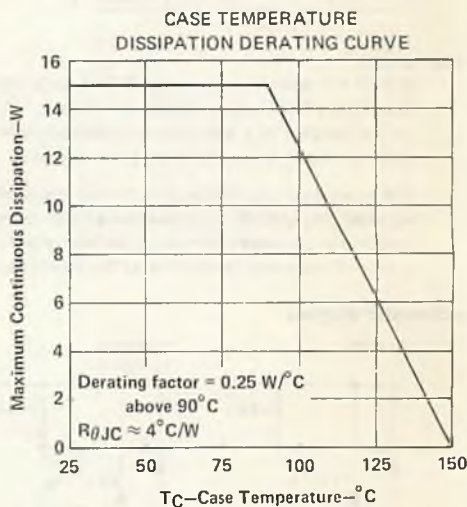


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	LM320-5	-7.5	-25	V
	LM320-12	-14.5	-32	
	LM320-15	-17.5	-35	
Output current, I_O	LM320-5		1.5	A
	LM320-12		1	
	LM320-15		1	
Operating virtual junction temperature, T_J		0	125	°C

TYPE SERIES LM320

3-TERMINAL NEGATIVE-VOLTAGE REGULATORS

LM320-5 electrical characteristics at specified virtual junction temperature, $I_O = 5 \text{ mA}$, $V_I = -10 \text{ V}$, (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	$T_J = 25^\circ\text{C}$		-4.8		-5.2	V
	$V_I = -7.5 \text{ V to } -25 \text{ V}$, $P \leq 15 \text{ W}$	$I_O = 5 \text{ mA to } 1.5 \text{ A}$, $T_J = 0^\circ\text{C to } 125^\circ\text{C}$	-4.75		-5.25	
Input regulation	$V_I = -7.5 \text{ V to } -25 \text{ V}$	$T_J = 25^\circ\text{C}$		10	40	mV
Ripple rejection	$f = 120 \text{ Hz}$	$T_J = 0^\circ\text{C to } 125^\circ\text{C}$	54	64		dB
Output regulation	$I_O = 5 \text{ mA to } 1.5 \text{ A}$	$T_J = 25^\circ\text{C}$		50	100	mV
Output noise voltage	$C_L = 1 \mu\text{F}$, $f = 10 \text{ Hz to } 100 \text{ kHz}$	$T_J = 25^\circ\text{C}$		150		μV
Output voltage long-term drift (see Note 2)	After 1000 h at $T_J = 125^\circ\text{C}$	$T_J = 25^\circ\text{C}$		10		mV
Bias current	$V_I = -7.5 \text{ V to } -25 \text{ V}$	$T_J = 0^\circ\text{C to } 125^\circ\text{C}$		1	2	mA
Bias current change	$V_I = -7.5 \text{ V to } -25 \text{ V}$	$T_J = 25^\circ\text{C}$		0.1	0.4	mA
	$I_O = 5 \text{ mA to } 1.5 \text{ A}$			0.1	0.4	

LM320-12 electrical characteristics at specified virtual junction temperature, $I_O = 5 \text{ mA}$, $V_I = -17 \text{ V}$, (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	$T_J = 25^\circ\text{C}$		-11.6	-12	-12.4	V
	$V_I = -14.5 \text{ V to } -32 \text{ V}$, $P \leq 15 \text{ W}$	$I_O = 5 \text{ mA to } 1 \text{ A}$, $T_J = 0^\circ\text{C to } 125^\circ\text{C}$	-11.4		-12.6	
Input regulation	$V_I = -14.5 \text{ V to } -32 \text{ V}$	$T_J = 25^\circ\text{C}$		4	20	mV
Ripple rejection	$f = 120 \text{ Hz}$	$T_J = 0^\circ\text{C to } 125^\circ\text{C}$	56	80		dB
Output regulation	$I_O = 5 \text{ mA to } 1 \text{ A}$	$T_J = 25^\circ\text{C}$		30	80	mV
Output noise voltage	$C_L = 1 \mu\text{F}$, $f = 10 \text{ Hz to } 100 \text{ kHz}$	$T_J = 25^\circ\text{C}$		400		μV
Output voltage long-term drift (see Note 2)	After 1000 h at $T_J = 125^\circ\text{C}$	$T_J = 25^\circ\text{C}$		24		mV
Bias current	$V_I = -14.5 \text{ V to } -32 \text{ V}$	$T_J = 0^\circ\text{C to } 125^\circ\text{C}$		2	4	mA
Bias current change	$V_I = -14.5 \text{ V to } -32 \text{ V}$	$T_J = 25^\circ\text{C}$		0.1	0.4	mA
	$I_O = 5 \text{ mA to } 1 \text{ A}$			0.1	0.4	

LM320-15 electrical characteristics at specified virtual junction temperature, $I_O = 5 \text{ mA}$, $V_I = -20 \text{ V}$, (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	$T_J = 25^\circ\text{C}$		-14.5	-15	-15.5	V
	$V_I = -17.5 \text{ V to } -35 \text{ V}$, $P \leq 15 \text{ W}$	$I_O = 5 \text{ mA to } 1 \text{ A}$, $T_J = 0^\circ\text{C to } 125^\circ\text{C}$	-14.3		-15.7	
Input regulation	$V_I = -17.5 \text{ V to } -35 \text{ V}$	$T_J = 25^\circ\text{C}$		5	20	mV
Ripple rejection	$f = 120 \text{ Hz}$	$T_J = 0^\circ\text{C to } 125^\circ\text{C}$	56	80		dB
Output regulation	$I_O = 5 \text{ mA to } 1 \text{ A}$	$T_J = 25^\circ\text{C}$		30	80	mV
Output noise voltage	$C_L = 1 \mu\text{F}$, $f = 10 \text{ Hz to } 100 \text{ kHz}$	$T_J = 25^\circ\text{C}$		400		μV
Output voltage long-term drift (see Note 2)	After 1000 h at $T_J = 125^\circ\text{C}$	$T_J = 25^\circ\text{C}$		30		mV
Bias current	$V_I = -17.5 \text{ V to } -35 \text{ V}$	$T_J = 0^\circ\text{C to } 125^\circ\text{C}$		2	4	mA
Bias current change	$V_I = -17.5 \text{ V to } -35 \text{ V}$	$T_J = 25^\circ\text{C}$		0.1	0.4	mA
	$I_O = 5 \text{ mA to } 1 \text{ A}$			0.1	0.4	

† All characteristics are measured with a $1 \mu\text{F}$ capacitor across the input and a $2 \mu\text{F}$ solid-tantalum capacitor across the output. All characteristics except ripple rejection and output noise voltage are measured using pulse techniques ($t_W \leq 10 \text{ ms}$, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

NOTE 2: Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPE SERIES LM320

3-TERMINAL NEGATIVE-VOLTAGE REGULATORS

TYPICAL CHARACTERISTICS

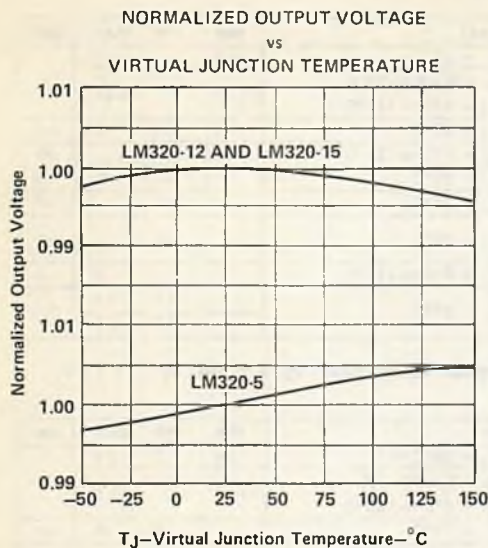


FIGURE 3

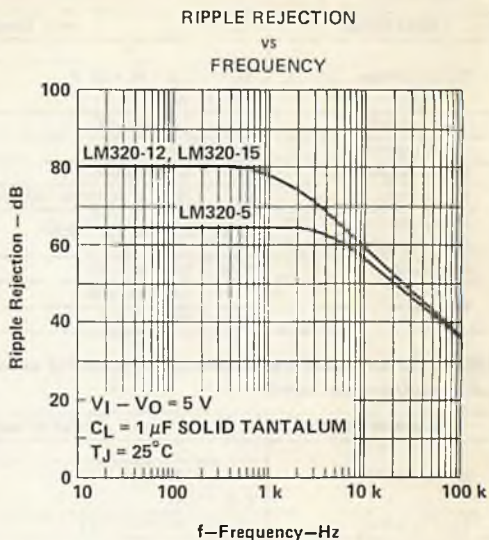


FIGURE 4

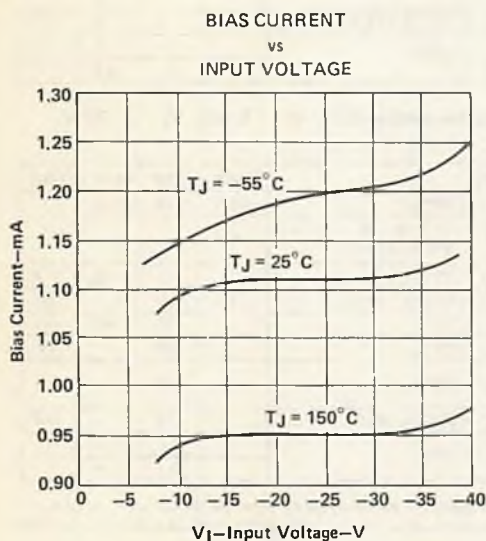


FIGURE 5

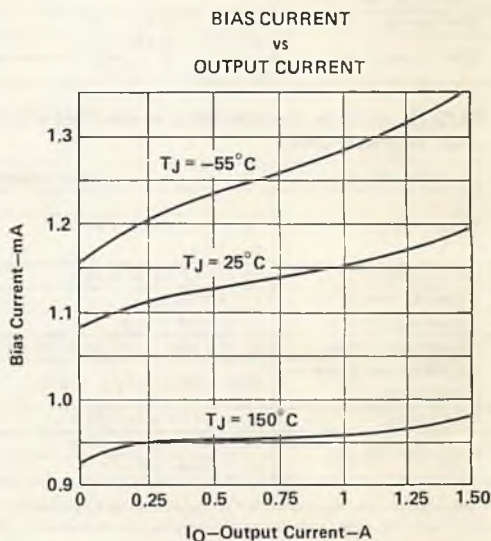


FIGURE 6

TYPICAL CHARACTERISTICS

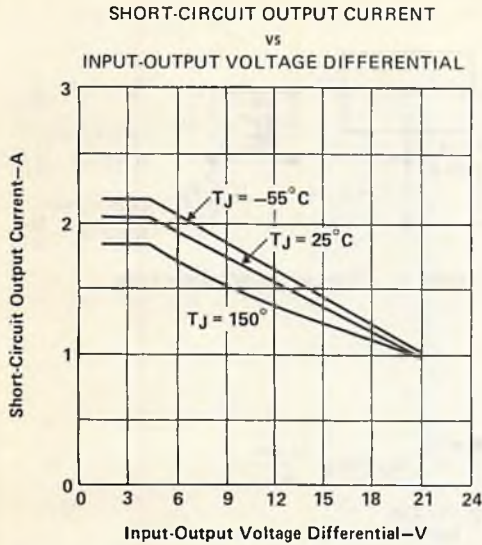


FIGURE 7

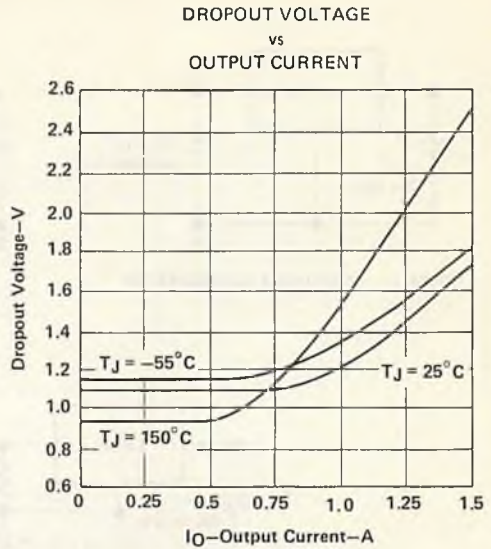


FIGURE 8

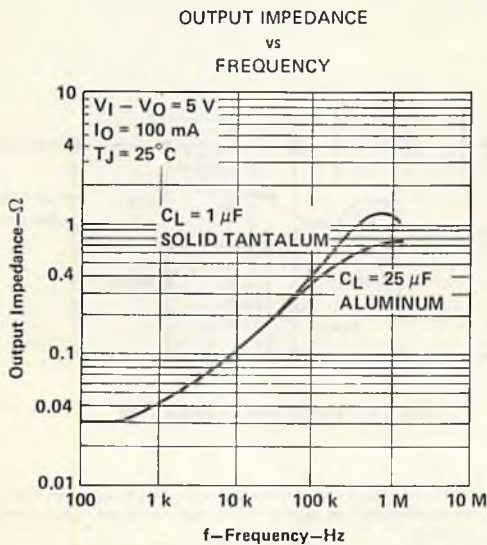


FIGURE 9

TYPE SERIES LM320

3-TERMINAL NEGATIVE-VOLTAGE REGULATORS

TYPICAL APPLICATION INFORMATION

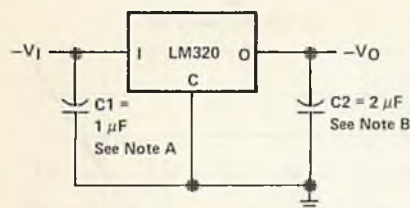


FIGURE 10 — FIXED-VOLTAGE REGULATOR

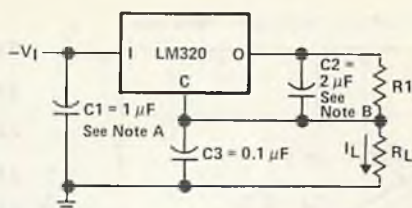


FIGURE 11 — CURRENT SOURCE REGULATOR

LM320-5
 $I_L = 1 \text{ mA} + \frac{5 \text{ V}}{R_1}$

LM320-12KC
 $I_L = 2 \text{ mA} + \frac{12 \text{ V}}{R_1}$

LM320-15KC
 $I_L = 2 \text{ mA} + \frac{15 \text{ V}}{R_1}$

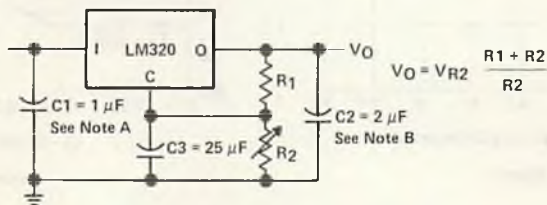


FIGURE 12 — ADJUSTABLE OUTPUT REGULATOR

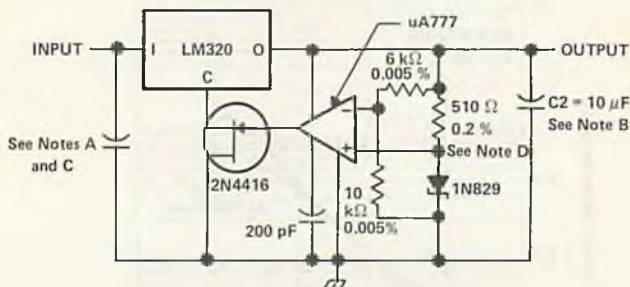
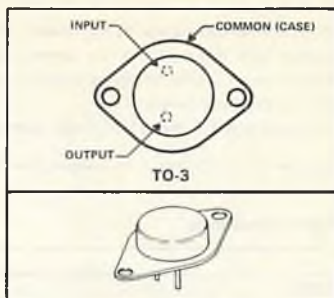


FIGURE 13 — HIGH-STABILITY REGULATOR

- NOTES: A. Capacitor C1 is required if the regulator is not located within 75 mm (3 inches) of the power supply filter.
- B. Capacitor C2 is required for stability. For the value given, the capacitor must be solid tantalum but a 25-μF aluminum electrolytic may be substituted. Values given may be increased without limit.
- C. In Figure 13 capacitor C1 is solid tantalum.
- D. This resistor determines zener current. Adjust to minimize thermal drift.

- 3-A Output Current Capability
- 2.5-V Dropout Voltage
- Thermal Shutdown Protection
- Internal Current Limiting Protection
- Output Impedance . . . 0.01Ω Typ
- Power Dissipation up to 30 W
- Direct Replacement for National Semiconductor LM323

KA PACKAGE
(TOP VIEW)



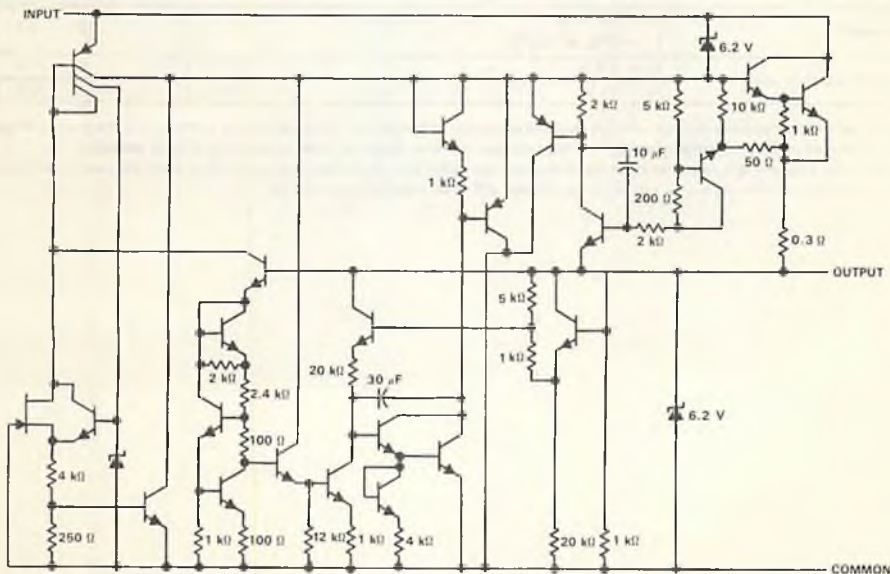
description

The LM323 is a three-terminal, fixed-positive-voltage regulator with a 5-volt output and a load driving capability of 3 amperes. The LM323 provides high output current capabilities through new circuit design and processing without sacrificing the regulation characteristics of lower-current devices.

The internal current-limiting and thermal-shutdown features make this device essentially immune to overload. The LM323 requires no external components for fixed-voltage operation, however if the device is more than four inches from the input filter capacitor, a 1-microfarad solid-tantalum capacitor should be used at the input. A 0.1-microfarad capacitor at the output may be used to improve output transient response. In addition to its use as a fixed-voltage regulator, the LM323 can be used with external components to obtain adjustable output voltages and currents and can also be used as the power-pass element in precision regulators.

The LM323 is characterized for operation from 0°C to 125°C .

schematic diagram



Component values shown are nominal.

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TEXAS INSTRUMENTS
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POST OFFICE BOX 225012 • DALLAS, TEXAS 75265

TYPE LM323

3-AMP, 5-VOLT POSITIVE REGULATOR

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input voltage	20 V
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 1)	3.5 W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	30 W
Operating free-air, case, or virtual junction temperature range	-55°C to 150°C
Storage temperature range	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	300°C

NOTE 1: For operation above 25°C free-air temperature, refer to Figure 1. For operation above 25°C case temperature, refer to Figure 2.

recommended conditions

	MIN	NOM	MAX	UNIT
Input voltage	7.5		15	V
Output current			3	A
Operating virtual junction temperature range, T_J	0		125	°C

electrical characteristics at 25°C virtual junction temperature, $P \leq 30$ W (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output voltage	$V_I = 7.5$ V, $I_O = 0$	4.8	5	5.2	V
	$V_I = 7.5$ V to 15 V, $I_O = 0$ to 3 A, $P \leq 30$ W, $T_J = 0^\circ\text{C}$ to 125°C	4.75		5.25	
Input regulation	$V_I = 7.5$ V to 15 V, See Note 2		5	25	mV
Output regulation	$V_I = 7.5$ V, $I_O = 0$ to 3 A, See Note 2		25	100	mV
Output noise voltage	$f = 100$ Hz to 100 kHz		40		μV
Output voltage long-term drift (see Note 3)	After 1000 h at T_J and V_I both at maximum rated values			35	mV
Bias current	$V_I = 7.5$ V to 15 V, $I_O = 0$ to 3 A, $T_J = 0^\circ\text{C}$ to 125°C		12	20	mA
Short-circuit output current	$V_I = 7.5$ V		4	5	A
	$V_I = 15$ V		3	4.5	

- NOTES: 2. Input regulation and output regulation are measured using pulse techniques ($t_W \leq 1$ ms, duty cycle $\leq 5\%$) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.
3. Since long-term drift cannot be measured on the individual device prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

THERMAL INFORMATION

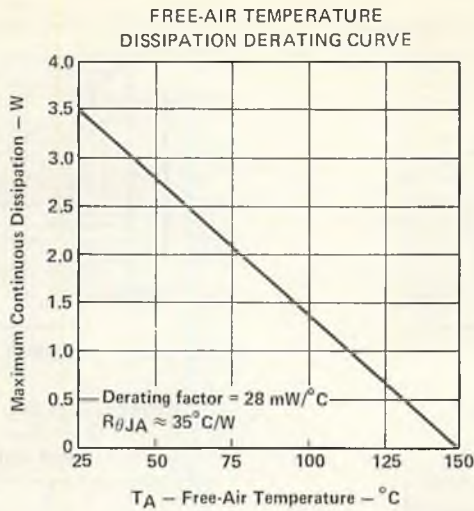


FIGURE 1

2

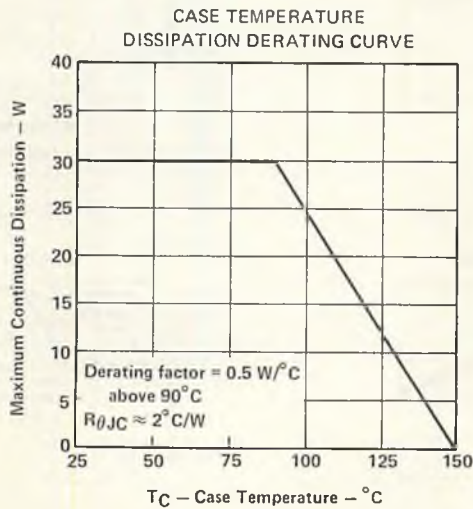


FIGURE 2

TYPE LM323

3-AMP, 5-VOLT POSITIVE REGULATOR

TYPICAL CHARACTERISTICS

OUTPUT VOLTAGE
VS
VIRTUAL JUNCTION TEMPERATURE

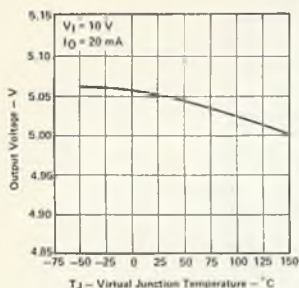


FIGURE 3

OUTPUT NOISE VOLTAGE
VS
FREQUENCY

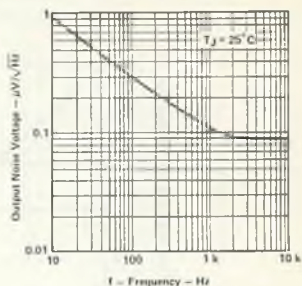


FIGURE 4

BIAS CURRENT
VS
INPUT VOLTAGE

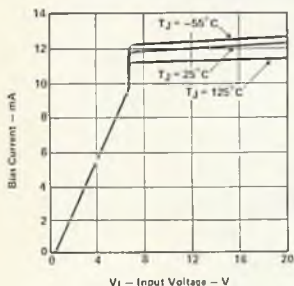


FIGURE 5

SHORT CIRCUIT OUTPUT CURRENT
VS
INPUT VOLTAGE

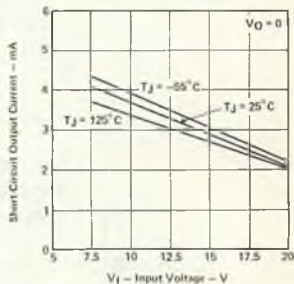


FIGURE 6

PEAK OUTPUT CURRENT
VS
INPUT VOLTAGE

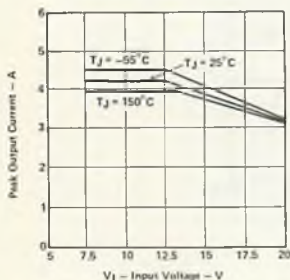


FIGURE 7

RIPPLE REJECTION
VS
FREQUENCY

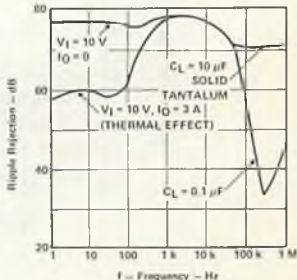


FIGURE 8

TYPICAL CHARACTERISTICS

OUTPUT IMPEDANCE
VS
FREQUENCY

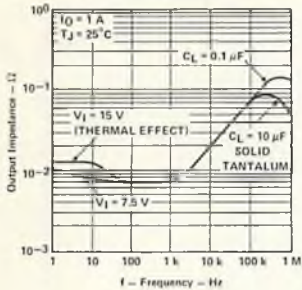


FIGURE 9

DROPOUT VOLTAGE
VS
VIRTUAL JUNCTION TEMPERATURE

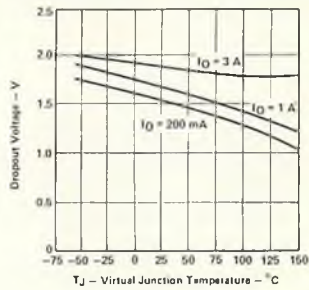


FIGURE 10

INPUT TRANSIENT RESPONSE

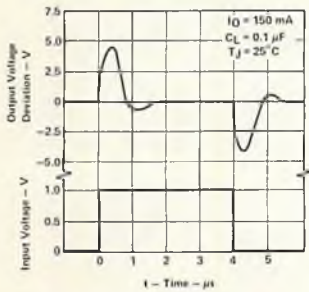


FIGURE 11

LOAD TRANSIENT RESPONSE

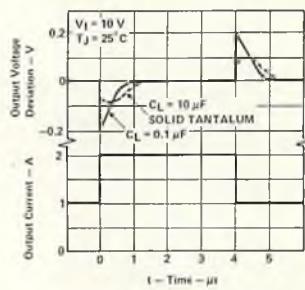
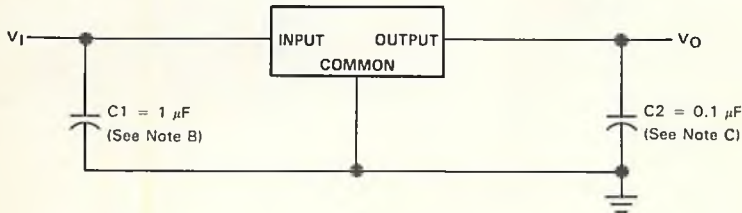


FIGURE 12

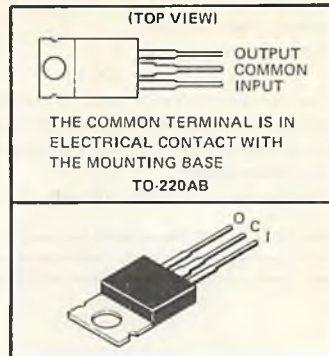
TYPICAL APPLICATIONS DATA



- NOTES: A. All capacitors are solid tantalum.
B. Use of capacitor C1 is required if regulator is more than 10 cm (4 inches) from filter capacitor.
C. Use of capacitor C2 (optional) improves transient response time.

- Input-Output Differential Less than 0.6 V
- Output Current of 150 mA
- Reverse Polarity Protection
- Line Transient Protection
- Internal Short-Circuit Current Limiting
- Internal Thermal Overload Protection
- Mirror-Image Insertion Protection
- Direct Replacement for National LM330T-5.0

KC PACKAGE



description

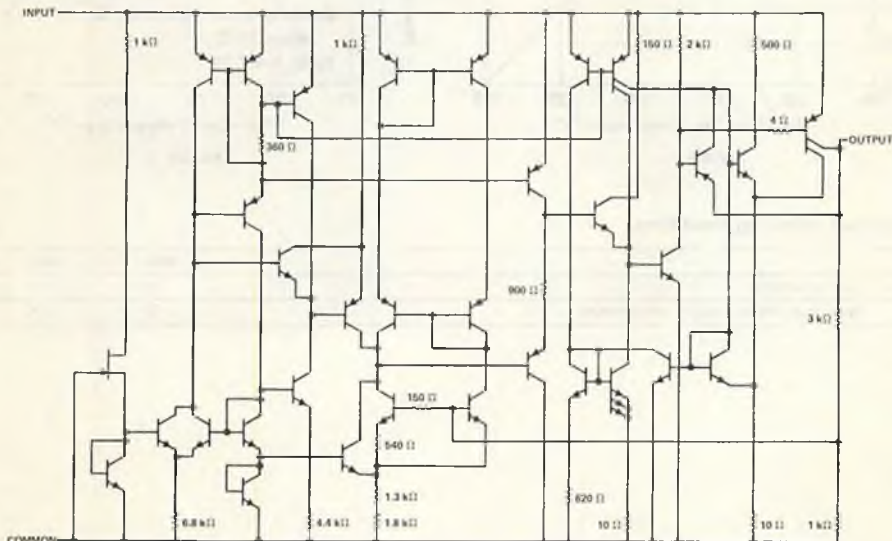
The LM330 3-terminal positive regulator features an ability to source 150 milliamperes of output current with an input-output differential of 0.6 volt or less. Familiar regulator features such as current limit and thermal overload protection are also provided.

The LM330 has low dropout voltage making it useful for certain battery applications. For example, since the low dropout voltage allows a longer battery discharge before the output falls out of regulation, a battery supplying the regulator input voltage may discharge to 5.6 volts and still properly regulate the system and load voltage. The LM330 protects both itself and the regulated system from reverse installation of batteries.

Other protection features include line transient protection above 40 volts, where the output actually shuts down to avoid damaging internal and external circuits. The LM330 regulator cannot be harmed by temporary mirror-image insertion.

2

schematic diagram



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TEXAS INSTRUMENTS
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POST OFFICE BOX 225012 • DALLAS, TEXAS 75265

TYPE LM330
3-TERMINAL POSITIVE REGULATOR

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Continuous input voltage	26 V
Transient input voltage $t = 1 \text{ s}$	50 V
$t = 100 \text{ ms}$	60 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) case temperature (see Note 1)	20 W
Operating free-air, case, or virtual junction temperature	-55°C to 150°C
Storage temperature	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation.

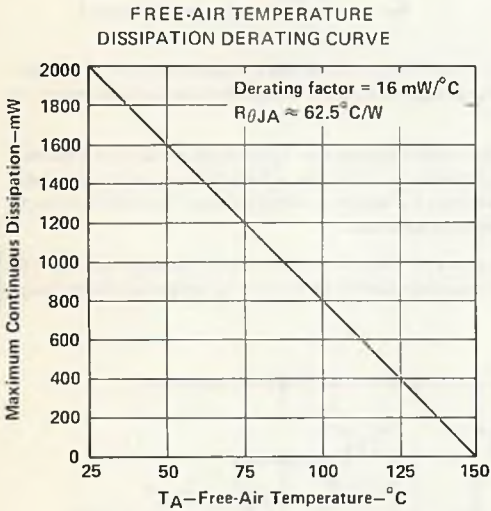


FIGURE 1

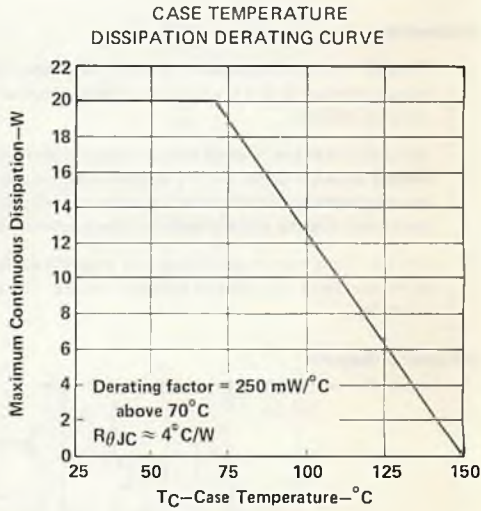


FIGURE 2

recommended operating conditions

	MIN	MAX	UNIT
I_O Output current	5	150	mA
T_A Operating virtual junction temperature	0	100	°C

TYPE LM330

3-TERMINAL POSITIVE REGULATOR

electrical characteristics at 25°C virtual junction temperature, $V_I = 14\text{ V}$, $I_O = 150\text{ mA}$,
(unless otherwise noted)

PARAMETERS	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	$V_I = 6\text{ V to }26\text{ V}$, $T_J = 0^\circ\text{C to }100^\circ\text{C}$	$I_O = 5\text{ mA to }150\text{ mA}$	4.8	5	5.2	V
			4.75		5.25	
Input regulation	$I_O = 5\text{ mA}$	$V_I = 9\text{ V to }16\text{ V}$		7	25	mV
		$V_I = 6\text{ V to }26\text{ V}$		30	60	
Ripple rejection	$f = 120\text{ Hz}$			56		dB
Output regulation	$I_O = 5\text{ mA to }150\text{ mA}$			14	50	mV
Output voltage long-term drift‡	After 1000 h at $T_J = 100^\circ\text{C}$			20		mV
Dropout voltage	$I_O = 150\text{ mA}$		0.32	0.6		V
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$			50		µV
Output voltage with input polarity reversed	$R_L = 100\ \Omega$	$V_I = -30\text{ V}$, $t = 100\text{ ms}$	> -0.3			V
		$V_I = -12\text{ V}$, DC	> -0.3			
Output voltage with input transient	$V_I = 60\text{ V}$,	$t = 100\text{ ms}$	< 5.5			V
	$V_I = 50\text{ V}$,	$t = 1\text{ s}$	< 5.5			
Bias current with input transient	$R_L = 100\ \Omega$	$V_I = 40\text{ V}$, $t = 1\text{ s}$	14			mA
		$V_I = -6\text{ V}$, $t = 1\text{ s}$	-80			
Overvoltage shutdown voltage			26	45		V
Output impedance	$I_O = 100\text{ mA}$, $I_O = 10\text{ mA (rms)}$, $f = 100\text{ Hz to }10\text{ kHz}$			200		mΩ
Bias current	$I_O = 10\text{ mA}$			3.5	7	mA
	$I_O = 50\text{ mA}$			5	11	
	$I_O = 150\text{ mA}$			18	40	
Bias current change	$V_I = 6\text{ V to }26\text{ V}$			10		%
Peak output current			150	420	700	mA

† Unless otherwise specified, all characteristics except ripple rejection and noise voltage measurements are measured using pulse techniques ($t_W \leq 10\text{ ms}$, duty cycle $\leq 5\%$) with a capacitor of $0.1\ \mu\text{F}$ across the input and a capacitor of $10\ \mu\text{F}$ across the output. Output voltage changes due to changes in internal temperature must be taken into account separately.

‡ Since long term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPE LM330

3-TERMINAL POSITIVE REGULATOR

TYPICAL CHARACTERISTICS

OUTPUT VOLTAGE
VS
VIRTUAL JUNCTION TEMPERATURE

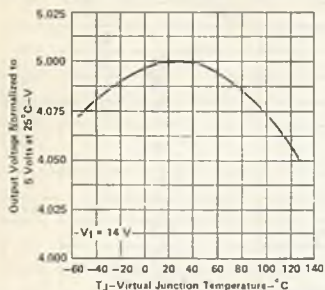


FIGURE 3

OUTPUT VOLTAGE
VS
INPUT VOLTAGE

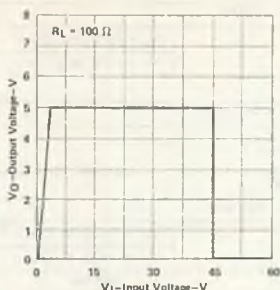


FIGURE 4

OUTPUT VOLTAGE
VS
INPUT VOLTAGE

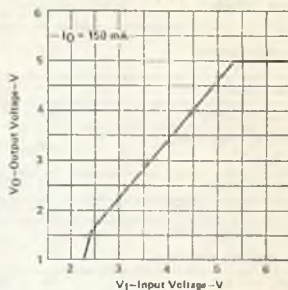


FIGURE 5

PEAK OUTPUT CURRENT
VS
INPUT VOLTAGE

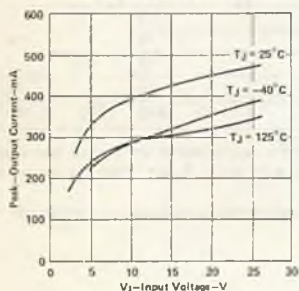


FIGURE 6

RIPPLE REJECTION
VS
FREQUENCY

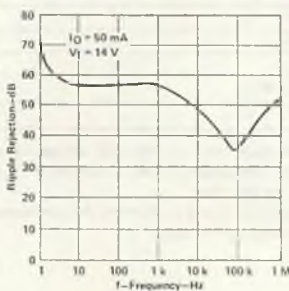


FIGURE 7

RIPPLE REJECTION
VS
OUTPUT CURRENT

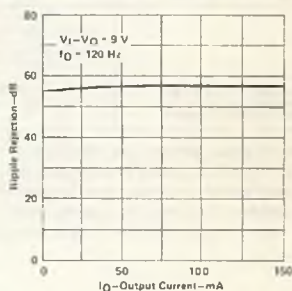


FIGURE 8

DROPOUT VOLTAGE
VS
VIRTUAL JUNCTION TEMPERATURE

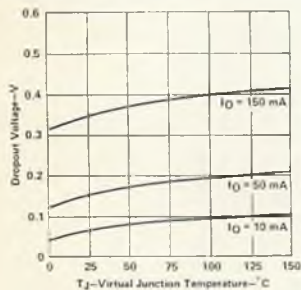


FIGURE 9

DROPOUT VOLTAGE
VS
OUTPUT CURRENT

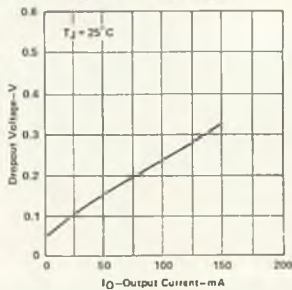


FIGURE 10

OUTPUT IMPEDANCE
VS
FREQUENCY

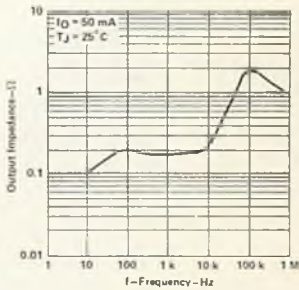


FIGURE 11

TYPICAL CHARACTERISTICS

INPUT CURRENT
VS
INPUT VOLTAGE

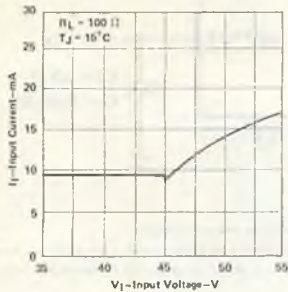


FIGURE 12

LINE TRANSIENT RESPONSE

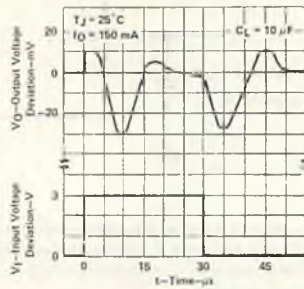


FIGURE 13

INPUT CURRENT
VS
REVERSE INPUT VOLTAGE

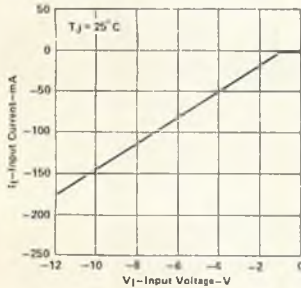


FIGURE 14

OUTPUT VOLTAGE
VS
REVERSE INPUT VOLTAGE

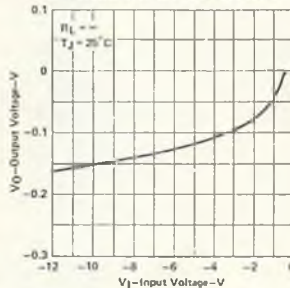


FIGURE 15

LOAD TRANSIENT RESPONSE

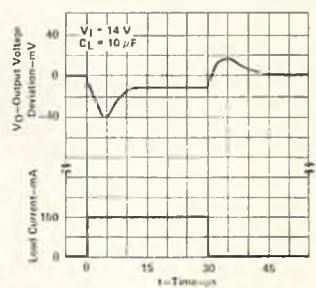


FIGURE 16

2

BIAS CURRENT
VS
OUTPUT CURRENT

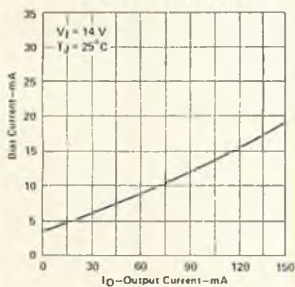


FIGURE 17

BIAS CURRENT
VS
VIRTUAL JUNCTION TEMPERATURE

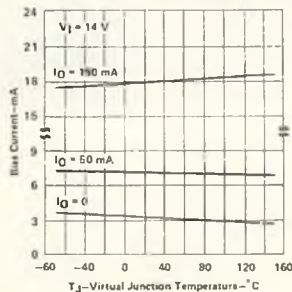


FIGURE 18

BIAS CURRENT
VS
INPUT VOLTAGE

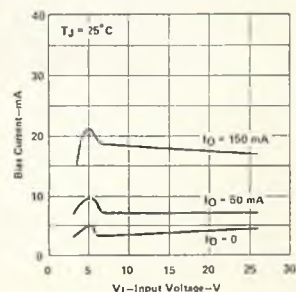
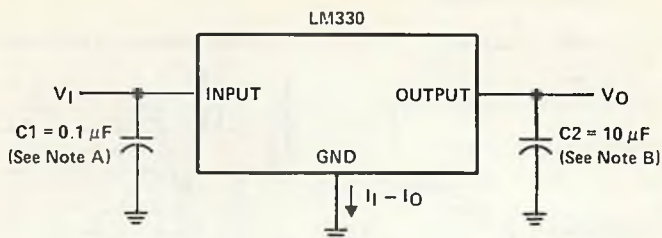


FIGURE 19

TYPE LM330

3-TERMINAL POSITIVE REGULATOR

TYPICAL APPLICATION DATA



- NOTES: A. Use of C1 is required if the regulator is not located in close proximity to the supply filter.
- B. Capacitor C2 must be located as close as possible to the regulator and may be an aluminum or tantalum type capacitor. The minimum capacitance that will provide stability is 10 μF . The capacitor must be rated for operation at $-40^\circ C$ to guarantee stability to that extreme.

FIGURE 20

- 3-Terminal Regulators
- Output Current up to 1.5 A
- No External Components
- Internal Thermal Overload
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Output Load Regulation . . . 0.3% Typ
- Direct Replacements for National LM340 Series

NOMINAL OUTPUT VOLTAGE	REGULATOR
5 V	LM340-5
12 V	LM340-12
15 V	LM340-15

description

This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Any of these regulators can deliver up to 1.5 amperes of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also as the power-pass element in precision regulators.

KC PACKAGE

(TOP VIEW)



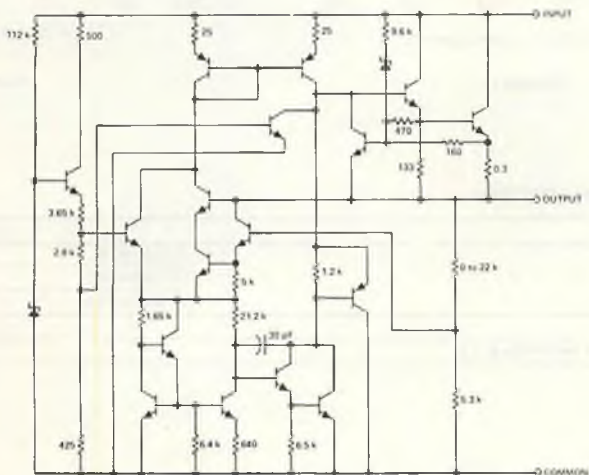
THE COMMON TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



2

schematic



Resistor values shown are nominal and in ohms.

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INCORPORATED**

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SERIES LM340

POSITIVE-VOLTAGE REGULATORS

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input voltage	35 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	15 W
Operating free-air, case, or virtual junction temperature range	-55°C to 150°C
Storage temperature range	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Curves, Figures 1 and 2.

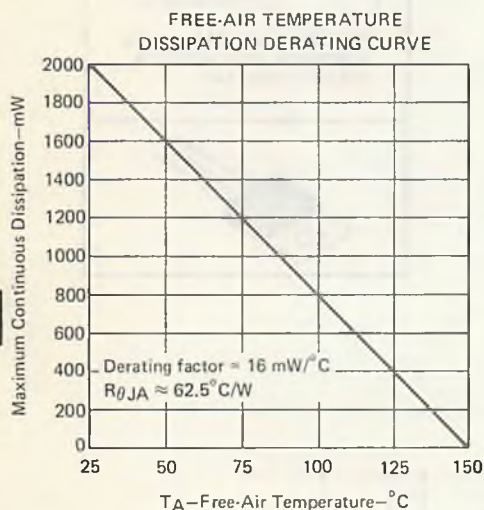


FIGURE 1

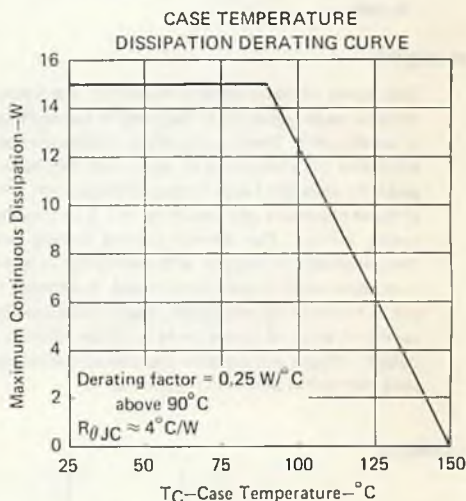


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	LM340-5	7	25	V
	LM340-12	14.5	30	
	LM340-15	17.5	30	
Output current, I_O			1.5	A
Operating virtual junction temperature, T_J		0	125	°C

SERIES LM340 POSITIVE-VOLTAGE REGULATORS

LM340-5 electrical characteristics at specified virtual junction temperature, $V_I = 10\text{ V}$, $I_O = 1\text{ A}$
(unless otherwise noted)

PARAMETER	TEST CONDITIONS [†]		MIN	TYP	MAX	UNIT
Output voltage	$I_O = 5\text{ mA to }1\text{ A}$	25°C	4.8	5	5.2	V
	$V_I = 7\text{ V to }20\text{ V}$, $P \leq 15\text{ W}$	$I_O = 5\text{ mA to }1\text{ A}$, $0^\circ\text{C to }125^\circ\text{C}$	4.75		5.25	
Input regulation	$I_O = 500\text{ mA}$	$V_I = 7\text{ V to }25\text{ V}$		3	50	mV
		$V_I = 8\text{ V to }20\text{ V}$			50	
	$I_O = 1\text{ A}$	$V_I = 7.3\text{ V to }20\text{ V}$			50	
		$V_I = 8\text{ V to }12\text{ V}$			25	
Ripple rejection	$V_I = 8\text{ V to }18\text{ V}$, $f = 120\text{ Hz}$	$I_O \leq 1\text{ A}$	62	80		dB
		$I_O \leq 500\text{ mA}$	62			
Output regulation	$I_O = 250\text{ mA to }750\text{ mA}$	25°C			25	mV
	$I_O = 5\text{ mA to }1.5\text{ A}$			10	50	
	$I_O = 5\text{ mA to }1\text{ A}$	$0^\circ\text{C to }125^\circ\text{C}$			50	
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C		40		μV
Dropout voltage	$I_O = 1\text{ A}$	25°C		2		V
Temperature coefficient of output voltage	$I_O = 5\text{ mA}$	$0^\circ\text{C to }125^\circ\text{C}$		-0.6		mV/ $^\circ\text{C}$
Output impedance	$f = 1\text{ kHz}$	25°C		8		m Ω
Bias current	$I_O \leq 1\text{ A}$	25°C			8	mA
		$0^\circ\text{C to }125^\circ\text{C}$			8.5	
Bias current change	$V_I = 7.5\text{ V to }20\text{ V}$, $I_O \leq 1\text{ A}$	25°C			1	mA
	$V_I = 7\text{ V to }25\text{ V}$, $I_O \leq 500\text{ mA}$	$0^\circ\text{C to }125^\circ\text{C}$			1	
	$I_O = 5\text{ mA to }1\text{ A}$				0.5	
Peak output current		25°C		2.4		A
Short-circuit current		25°C		2.1		A

[†] All characteristics are measured with a capacitor across the input of $0.22\text{ }\mu\text{F}$ and a capacitor across the output of $0.1\text{ }\mu\text{F}$. All characteristics except noise voltage rejection ratio are measured using pulse techniques ($t_W \leq 10\text{ ms}$, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

SERIES LM340 POSITIVE-VOLTAGE REGULATORS

LM340-12 electrical characteristics at specified virtual junction temperature, $V_I = 19\text{ V}$, $I_O = 1\text{ A}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	$I_O = 5\text{ mA to }1\text{ A}$	25°C	11.5	12	12.5	V
	$V_I = 14.5\text{ V to }27\text{ V}$, $I_O = 5\text{ mA to }1\text{ A}$, $P \leq 15\text{ W}$	$0^\circ\text{C to }125^\circ\text{C}$	11.4		12.6	
Input regulation	$I_O = 500\text{ mA}$	$V_I = 14.5\text{ V to }30\text{ V}$		4	120	mV
		$V_I = 15\text{ V to }27\text{ V}$			120	
	$I_O = 1\text{ A}$	$V_I = 14.6\text{ V to }27\text{ V}$			120	
		$V_I = 16\text{ V to }22\text{ V}$			120	
Ripple rejection	$V_I = 15\text{ V to }25\text{ V}$, $f = 120\text{ Hz}$	$I_O \leq 1\text{ A}$		55	72	dB
		$I_O \leq 500\text{ mA}$		55		
Output regulation	$I_O = 250\text{ mA to }750\text{ mA}$	25°C			60	mV
	$I_O = 5\text{ mA to }1.5\text{ A}$			12	120	
	$I_O = 5\text{ mA to }1\text{ A}$	$0^\circ\text{C to }125^\circ\text{C}$			120	
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C		75		μV
Dropout voltage	$I_O = 1\text{ A}$	25°C		2		V
Temperature coefficient of output voltage	$I_O = 5\text{ mA}$	$0^\circ\text{C to }125^\circ\text{C}$		-1.5		$\text{mV}/^\circ\text{C}$
Output impedance	$f = 1\text{ kHz}$	25°C		18		$\text{m}\Omega$
Bias current	$I_O \leq 1\text{ A}$	25°C			8	mA
		$0^\circ\text{C to }125^\circ\text{C}$			8.5	
Bias current change	$V_I = 14.8\text{ V to }27\text{ V}$, $I_O \leq 1\text{ A}$	25°C			1	mA
	$V_I = 14.5\text{ V to }30\text{ V}$, $I_O \leq 500\text{ mA}$	$0^\circ\text{C to }125^\circ\text{C}$			1	
	$I_O = 5\text{ mA to }1\text{ A}$				0.5	
Peak output current		25°C		2.4		A
Short-circuit current		25°C		1.5		A

† All characteristics are measured with a capacitor across the input of $0.22\text{ }\mu\text{F}$ and a capacitor across the output of $0.1\text{ }\mu\text{F}$. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10\text{ ms}$, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

SERIES LM340

POSITIVE-VOLTAGE REGULATORS

LM340-15 electrical characteristics at specified virtual junction temperature, $V_I = 23 \text{ V}$, $I_O = 1 \text{ A}$
(unless otherwise noted)

PARAMETER	TEST CONDITIONS [†]		MIN	TYP	MAX	UNIT
Output voltage	$I_O = 5 \text{ mA to } 1 \text{ A}$	25°C	14.4	15	15.6	V
	$V_I = 17.5 \text{ V to } 30 \text{ V}$, $I_O = 5 \text{ mA to } 1 \text{ A}$, $P \leq 15 \text{ W}$	$0^\circ\text{C to } 125^\circ\text{C}$	14.25		15.75	
Input regulation	$I_O = 500 \text{ mA}$	$V_I = 17.5 \text{ V to } 30 \text{ V}$		4	150	mV
		$V_I = 18.5 \text{ V to } 30 \text{ V}$			150	
	$I_O = 1 \text{ A}$	$V_I = 17.7 \text{ V to } 30 \text{ V}$			150	
		$V_I = 20 \text{ V to } 26 \text{ V}$			75	
Ripple rejection	$V_I = 18.5 \text{ V to } 28.5 \text{ V}$, $f = 120 \text{ Hz}$	$I_O \leq 1 \text{ A}$	54	70		dB
		$I_O \leq 500 \text{ mA}$	54			
Output regulation	$I_O = 250 \text{ mA to } 750 \text{ mA}$	25°C			75	mV
	$I_O = 5 \text{ mA to } 1.5 \text{ A}$			12	150	
	$I_O = 5 \text{ mA to } 1 \text{ A}$	$0^\circ\text{C to } 125^\circ\text{C}$			150	
Output noise voltage	$f = 10 \text{ Hz to } 100 \text{ kHz}$	25°C		90		μV
Dropout voltage	$I_O = 1 \text{ A}$	25°C		2		V
Temperature coefficient of output voltage	$I_O = 5 \text{ mA}$	$0^\circ\text{C to } 125^\circ\text{C}$		-1.8		mV/ $^\circ\text{C}$
Output impedance	$f = 1 \text{ kHz}$	25°C		19		m Ω
Bias current	$I_O \leq 1 \text{ A}$	25°C			8	mA
		$0^\circ\text{C to } 125^\circ\text{C}$			8.5	
Bias current change	$V_I = 17.9 \text{ V to } 30 \text{ V}$, $I_O \leq 1 \text{ A}$	25°C			1	mA
	$V_I = 17.5 \text{ V to } 30 \text{ V}$, $I_O \leq 500 \text{ mA}$	$0^\circ\text{C to } 125^\circ\text{C}$			1	
	$I_O = 5 \text{ mA to } 1 \text{ A}$				0.5	
Peak output current		25°C		2.4		A
Short-circuit current		25°C		1.2		A

[†] All characteristics are measured with a capacitor across the input of $0.22 \mu\text{F}$ and a capacitor across the output of $0.1 \mu\text{F}$. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10 \text{ ms}$, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

SERIES LM340 POSITIVE-VOLTAGE REGULATORS

TYPICAL CHARACTERISTICS

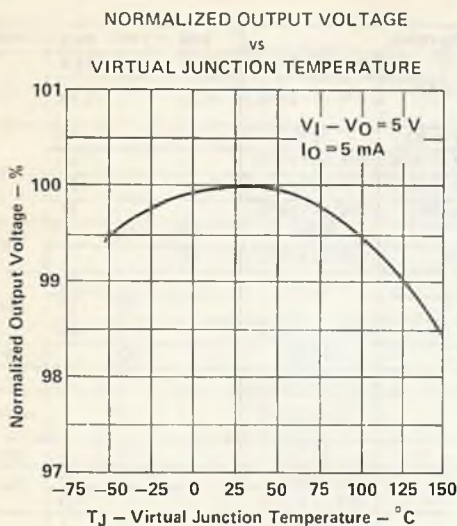


FIGURE 3

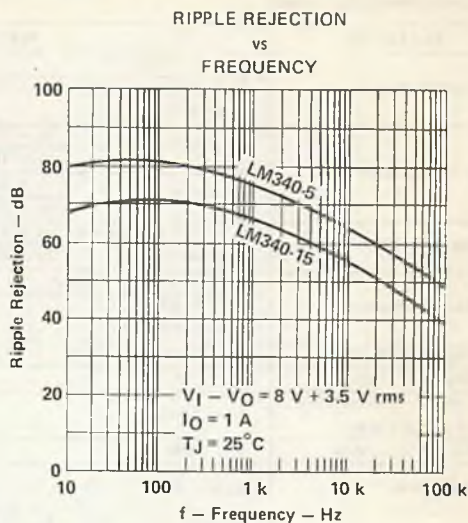


FIGURE 4

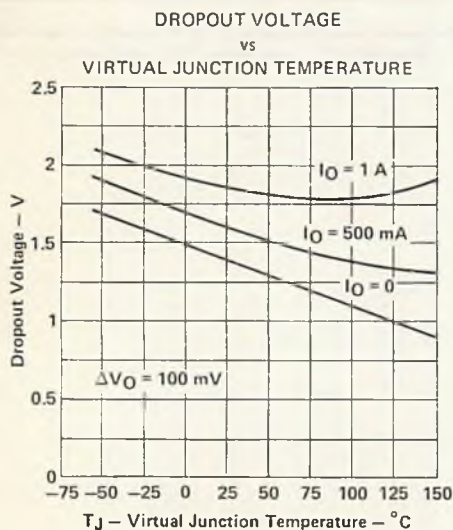


FIGURE 5

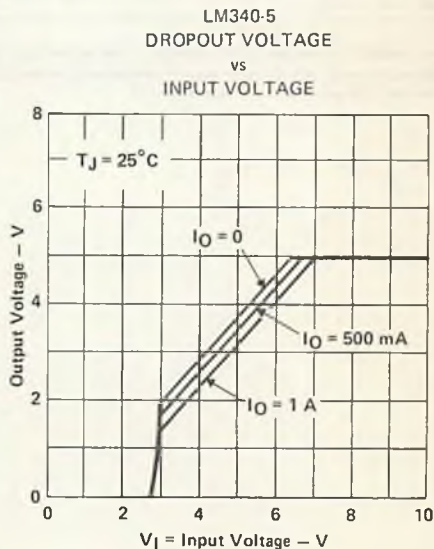


FIGURE 6

TYPICAL CHARACTERISTICS

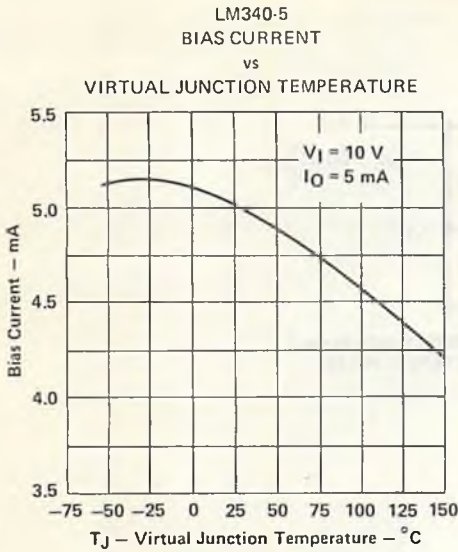


FIGURE 7

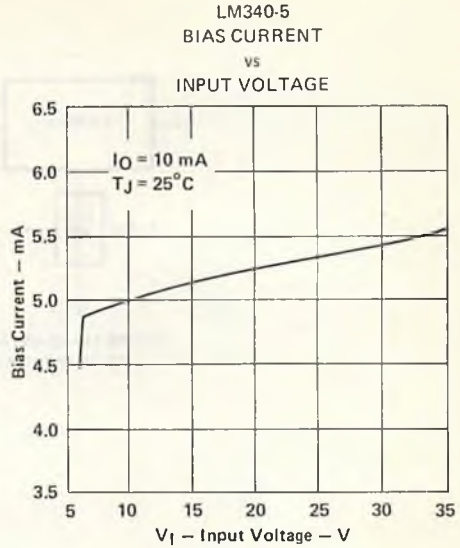


FIGURE 8

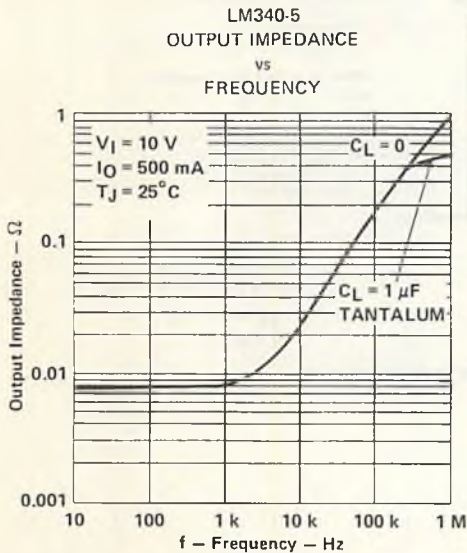


FIGURE 9

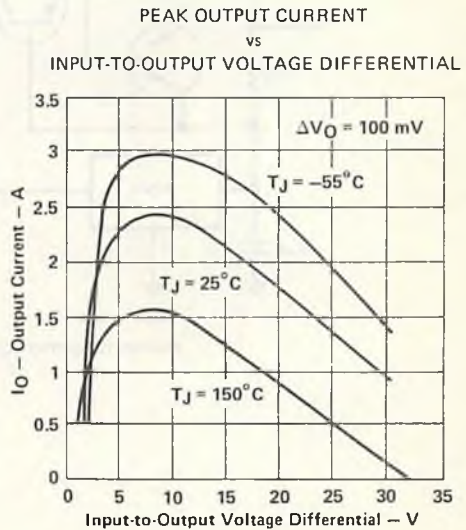


FIGURE 10

TYPICAL APPLICATION DATA

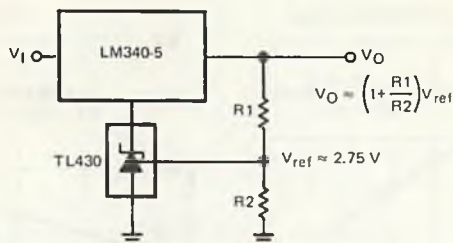


FIGURE 11—ADJUSTABLE SUPPLY WITH STABLE OUTPUT FROM 8 VOLTS TO 35 VOLTS

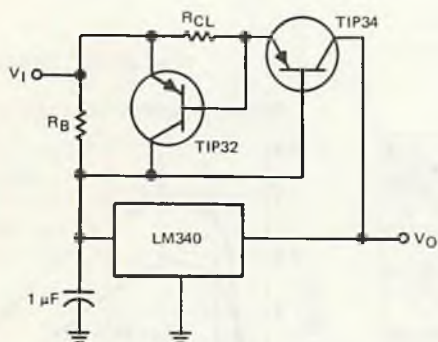


FIGURE 12—OUTPUT CURRENT BOOST CIRCUIT

The boost circuit takes over at a level determined by \$R_B\$.

$$R_B \approx \frac{0.6 \text{ V}}{I_B}$$

where \$I_B\$ is the LM340 operating level.

Maximum current limit \$I_{CL}\$ is determined by \$R_{CL}\$.

$$R_{CL} \approx \frac{0.6 \text{ V}}{I_{CL}}$$

Example: If \$I_B\$ is selected to be 0.5 A, then

$$R_B = 1.2 \Omega.$$

If \$I_{CL}\$ is 3 A, then

$$R_{CL} = 0.2 \Omega.$$

- Adjustable Output . . . 1.2 V to 33 V
- 3-A Output Current Capability
- Line Regulation . . . 0.005 %/V Typ
- Load Regulation . . . 0.1% Typ
- Current Limit Constant with Temperature
- Guaranteed Thermal Regulation
- Direct Replacement for National Semiconductor LM350

description

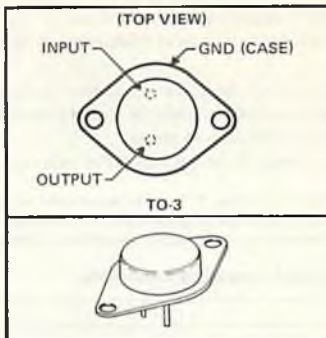
The LM350 is an adjustable 3-terminal positive-voltage regulator capable of supplying 3 amperes over an output voltage range of 1.2 volts to 33 volts. The device is easy to use and requires only two external resistors to set the output voltage. Both input and output regulation are better than standard fixed regulators.

In addition to higher performance than fixed regulators, the LM350 offers full overload protection available only in integrated circuits. Included on the chip are current limit, thermal overload protection, and safe-area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected. Normally, no capacitors are needed unless the device is situated far from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection, which is difficult to achieve with standard 3-terminal regulators.

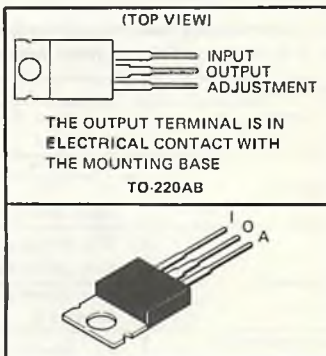
Besides replacing fixed regulators, the LM350 is useful in a wide variety of other applications. Even though the regulator is floating and sees only the input-to-output differential voltage, use of these devices to regulate voltages that would cause the maximum-rated differential voltage to be exceeded if the output became shorted to ground is not recommended. The TL783 or TL783A is recommended for output voltages exceeding 33 volts. The primary application of the LM350 is that of a programmable output regulator, but by connecting a fixed resistor between the adjustment terminal and the output terminal, this device can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground, which programs the output to 1.2 volts where most loads draw little current.

The LM350 is characterized for operation from 0°C to 125°C.

KA PACKAGE



KC PACKAGE



2

ADVANCE INFORMATION

This document contains information on a new product. Specifications are subject to change without notice.

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TYPE LM350

3-AMP ADJUSTABLE REGULATOR

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input-to-output voltage differential	35 V
Continuous total power dissipation at 25°C free-air temperature (see Note 1): KA package	3.5 W
KC package	2 W
Continuous total power dissipation at (or below) 25°C case temperature (see Note 1)	30 W
Operating free-air, case, or virtual junction temperature range	-55°C to 150°C
Storage temperature range	-65°C to 150°C
Lead temperature 1.6 mm (1/16 inch) from case for 60 seconds	260°C

NOTE 1: For operation above 25°C free-air temperature, refer to Figures 1 through 4. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation.

recommended operating conditions

	MIN	MAX	UNIT
Output current, I_O		3	A
Operating virtual junction temperature, T_J	0	125	°C

electrical characteristics over recommended ranges of operating virtual junction temperature, $V_I - V_O = 5$ V, $I_O = 1.5$ A (unless otherwise noted)

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input regulation (see Note 2)	$V_I - V_O = 3$ V to 35 V See Note 3	$T_J = 25^\circ\text{C}$ $T_J = 0^\circ\text{C to } 125^\circ\text{C}$	0.005	0.03		%/V
Ripple rejection	$V_O = 10$ V, $f = 120$ Hz			65		dB
	$V_O = 10$ V, 10- μF capacitor between ADJ and ground	$f = 120$ Hz	66			
Output regulation	$I_O = 10$ mA to 3 A, $T_J = 25^\circ\text{C}$, See Note 3	$V_O \leq 5$ V $V_O > 5$ V		5	25	mV
	$I_O = 10$ mA to 3 A, See Note 3	$V_O \leq 5$ V $V_O > 5$ V		0.1	0.5	%
				20	70	mV
				0.3	1.5	%
Output voltage change with temperature	$T_J = 0^\circ\text{C to } 125^\circ\text{C}$			1		%
Thermal regulation	$t_W = 20$ ms		0.002	0.03		%/W
Output voltage long-term drift (see Note 4)	After 1000 h at $T_J = 125^\circ\text{C}$			0.3	1	%
Output noise voltage	$f = 10$ Hz to 10 kHz, $T_J = 25^\circ\text{C}$		0.003			%
Minimum output current to maintain regulation	$V_I - V_O = 35$ V			3.5	10	mA
Peak output current	$V_I - V_O \leq 10$ V		3	4.5		A
	$V_I - V_O = 30$ V, $T_J = 25^\circ\text{C}$		0.25	1		
Adjustment-terminal current				50	100	μA
Change in adjustment-terminal current	$V_I - V_O = 3$ V to 35 V, $I_O = 10$ mA to 3 A			0.2	5	μA
Reference voltage (output to ADJ)	$V_I - V_O = 3$ V to 35 V, $I_O = 10$ mA to 3 A, $P \leq 30$ W		1.2	1.25	1.3	V

NOTES: 2. Input regulation is expressed as the percentage change in output voltage per 1-volt change at the input.

3. Input regulation and output regulation are measured using pulse techniques ($t_W \leq 10$ μs , duty cycle $\leq 5\%$) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.

4. Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

THERMAL INFORMATION

KA PACKAGE
FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

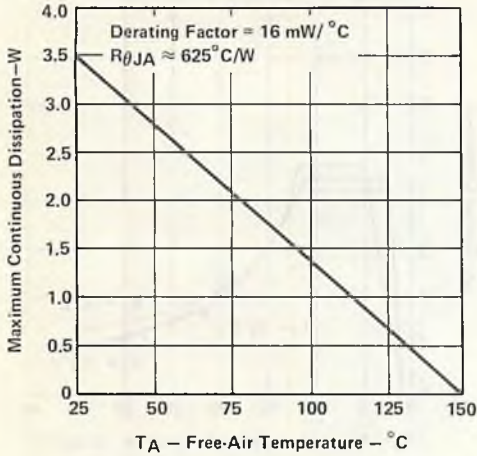


FIGURE 1

KA PACKAGE
CASE TEMPERATURE
DISSIPATION DERATING CURVE

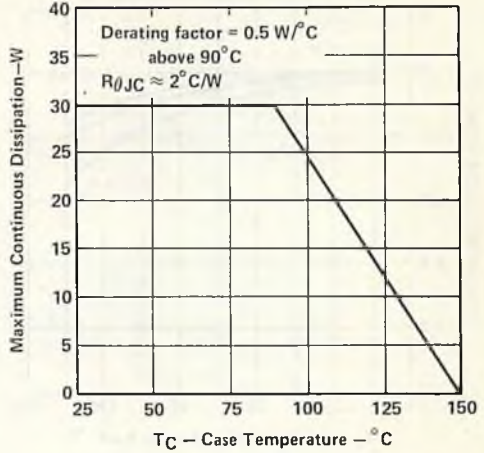


FIGURE 2

KC PACKAGE
FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

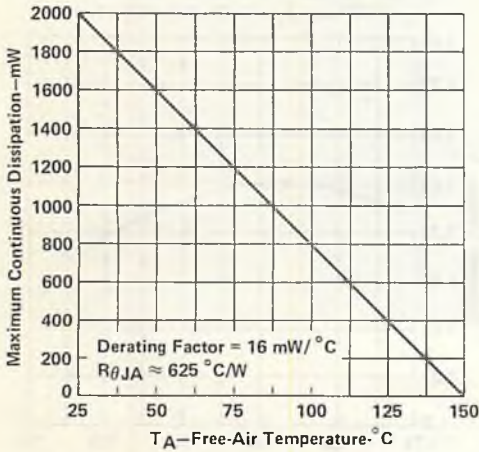


FIGURE 3

KC PACKAGE
POWER
VS
CASE TEMPERATURE

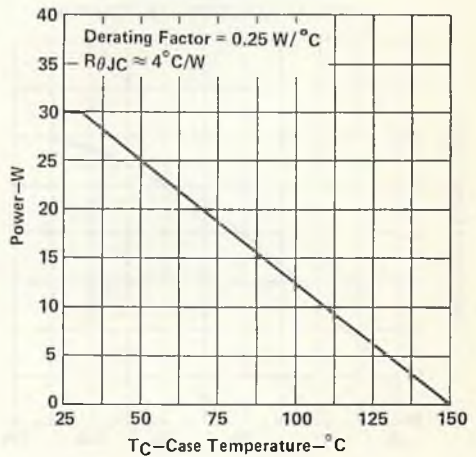


FIGURE 4

TYPE LM350

3-AMP ADJUSTABLE REGULATOR

TYPICAL CHARACTERISTICS

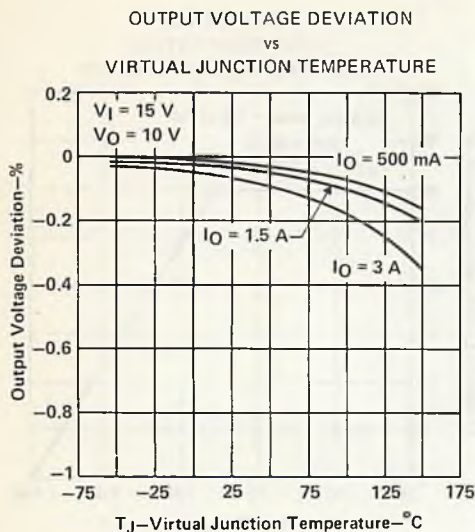


FIGURE 5

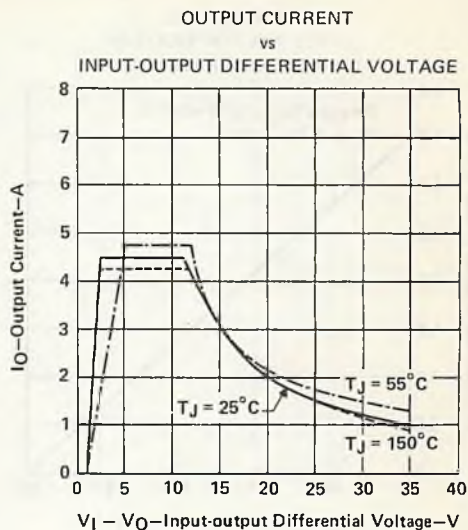


FIGURE 6

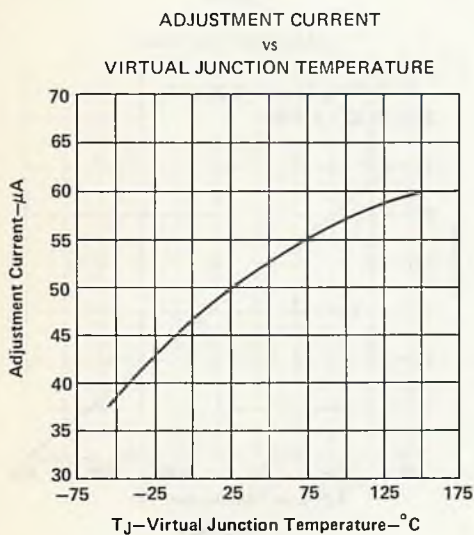


FIGURE 7

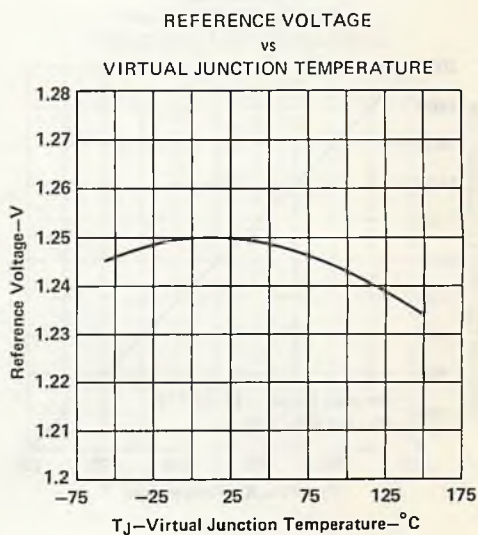
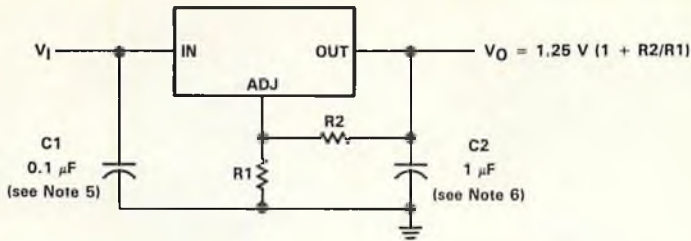


FIGURE 8

TYPICAL APPLICATION DATA



- NOTES: 5. Capacitor $C1$ is required if regulator is not located in close proximity to the power supply amplifier.
6. Capacitor $C2$ may be used to improve transient response.

1974-1976 (1977-1978) 1979-1980



- Input-Output Differential Less than 0.6 V
- Output Current of 150 mA
- Reverse Battery Protection
- Line Transient Protection
- 40-Volt Load-Dump Protection
- Internal Short-Circuit Current Limiting
- Internal Thermal Overload Protection
- Mirror-Image Insertion Protection
- Direct Replacement for National LM2930 Series

KC PACKAGE

(TOP VIEW)



THE COMMON TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



description

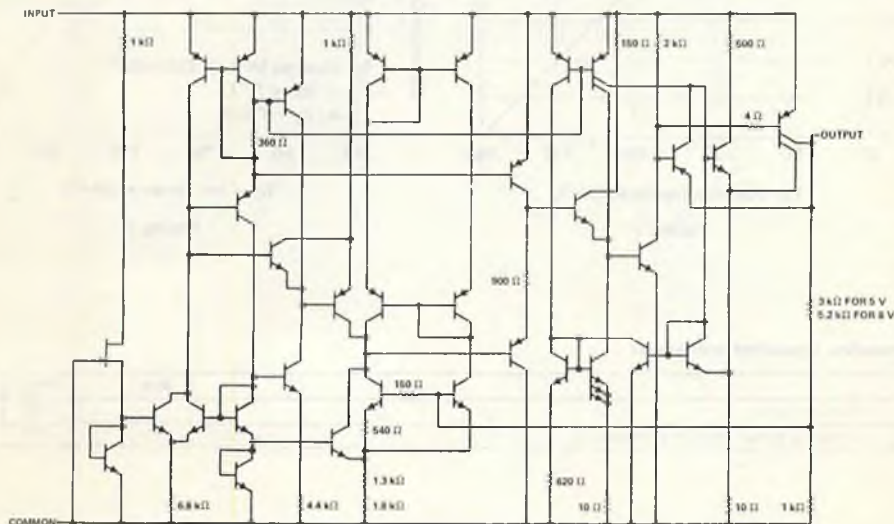
The LM2930-5 and LM2930-8 are 3-terminal positive regulators that provide fixed 5-volt and 8-volt regulated outputs. Each features the ability to source 150 milliamperes of output current with an input-output differential of 0.6 volt or less. Familiar regulator features such as current limit and thermal overload protection are also provided.

The LM2930 series has low voltage dropout making it useful for certain battery applications. For example, the low voltage dropout feature allows a longer battery discharge before the output falls out of regulation; the battery supplying the regulator input voltage may discharge to 5.6 volts and still properly regulate the system and load voltage. Supporting this feature, the LM2930 series protects both itself and the regulated system from reverse battery installation or two-battery jumps.

Other protection features include line transient protection for load-dump of up to 40 volts. In this case the regulator shuts down to avoid damaging internal and external circuits. The LM2930 series regulator cannot be harmed by temporary mirror-image insertion.

2

schematic diagram



All component values are nominal.

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**TEXAS INSTRUMENTS
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TYPES LM2930-5, LM2930-8
3-TERMINAL POSITIVE REGULATORS

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Continuous input voltage	26 V
Transient input voltage: t = 1 s	40 V
Continuous reverse input voltage	-6 V
Transient reverse input voltage: t = 100 ms	-12 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25°C case-temperature (see Note 1)	20 W
Operating free-air, case, or virtual junction temperature	-40°C to 150°C
Storage temperature range	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case to 10 seconds	260°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variation in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation.

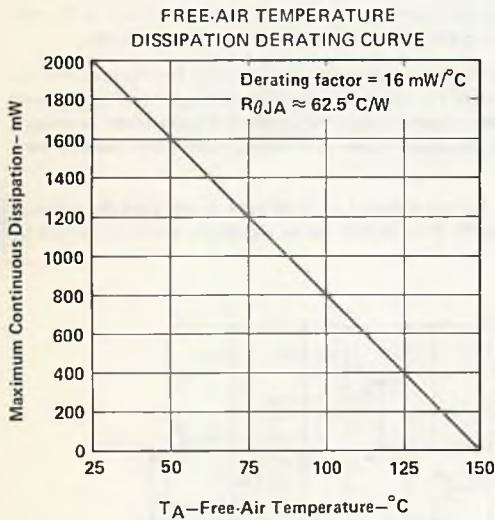


FIGURE 1

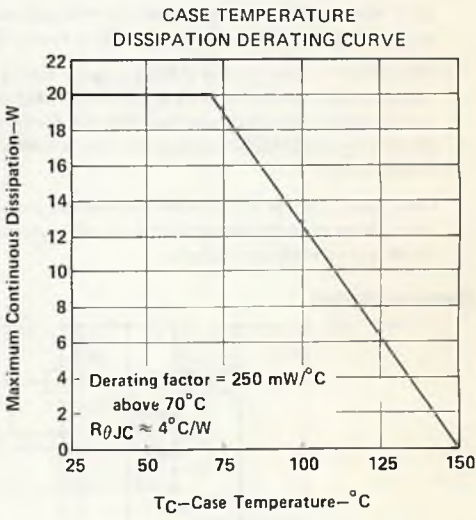


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
I_O	Output current		150	mA
T_J	Operating virtual junction temperature	-40	125	°C

TYPES LM2930-5, LM2930-8 3-TERMINAL POSITIVE REGULATORS

LM2930-5 electrical characteristics at 25°C virtual junction temperature, $V_I = 14\text{ V}$, $I_O = 150\text{ mA}$,
(unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	$V_I = 6\text{ V to } 26\text{ V}$, $T_J = -40^\circ\text{C to } 125^\circ\text{C}$	$I_O = 5\text{ mA to } 150\text{ mA}$	4.5	5	5.5	V
Input regulation	$I_O = 5\text{ mA}$	$V_I = 9\text{ V to } 16\text{ V}$ $V_I = 6\text{ V to } 26\text{ V}$		7 30	25 80	mV
Ripple rejection	$f = 120\text{ Hz}$			56		dB
Output regulation	$I_O = 5\text{ mA to } 150\text{ mA}$			14	50	mV
Output voltage long-term drift‡	After 1000 h at $T_J = 125^\circ\text{C}$			20		mV
Dropout voltage	$I_O = 150\text{ mA}$			0.32	0.6	V
Output noise voltage	$f = 10\text{ Hz to } 100\text{ kHz}$			60		µV
Output voltage during line transients	$V_I = -12\text{ V to } 40\text{ V}$, $R_L = 100\ \Omega$		-0.3		5.5	V
Output impedance	$I_O = 100\text{ mA}$, $I_O = 10\text{ mA (rms)}$, $f = 100\text{ Hz to } 10\text{ kHz}$			200		mΩ
Bias current	$I_O = 10\text{ mA}$			4	7	mA
	$I_O = 150\text{ mA}$			18	40	
Peak output current			150	300	700	mA

LM2930-8 electrical characteristics at 25°C virtual junction temperature, $V_I = 14\text{ V}$, $I_O = 150\text{ mA}$,
(unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	$V_I = 9.4\text{ V to } 26\text{ V}$, $T_J = -40^\circ\text{C to } 125^\circ\text{C}$	$I_O = 5\text{ mA to } 150\text{ mA}$	7.2	8	8.8	V
Input regulation	$I_O = 5\text{ mA}$	$V_I = 9.4\text{ V to } 16\text{ V}$ $V_I = 9.4\text{ V to } 26\text{ V}$		12 50	50 100	V
Ripple rejection	$f = 120\text{ Hz}$			52		dB
Output regulation	$I_O = 5\text{ mA to } 150\text{ mA}$			25	50	mV
Output voltage long-term drift‡	After 1000 h at $T_J = 125^\circ\text{C}$			30		mV
Dropout voltage	$I_O = 150\text{ mA}$			0.32	0.6	V
Output noise voltage	$f = 10\text{ Hz to } 100\text{ kHz}$			90		µV
Output voltage during line transients	$V_I = -12\text{ V to } 40\text{ V}$, $R_L = 100\ \Omega$		-0.3		8.8	V
Output impedance	$I_O = 100\text{ mA}$, $I_O = 10\text{ mA (rms)}$, $f = 100\text{ Hz to } 10\text{ kHz}$			300		mΩ
Bias current	$I_O = 10\text{ mA}$			4	7	mA
	$I_O = 150\text{ mA}$			18	40	
Peak output current			150	300	700	mA

† Unless otherwise specified, all characteristics, except ripple rejection and noise voltage measurements, are measured using pulse techniques ($t_W \leq 10\text{ ms}$, duty cycle $\leq 5\%$) with a capacitor of $0.1\ \mu\text{F}$ across the input and a capacitor of $10\ \mu\text{F}$ across the output. Output voltage changes due to changes in internal temperature must be taken into account separately.

‡ Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPES LM2930-5, LM2930-8 3-TERMINAL POSITIVE REGULATORS

TYPICAL CHARACTERISTICS

NORMALIZED OUTPUT VOLTAGE
VS
VIRTUAL JUNCTION TEMPERATURE

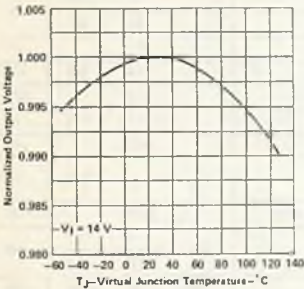


FIGURE 3

LM2930-5
OUTPUT VOLTAGE
VS
INPUT VOLTAGE

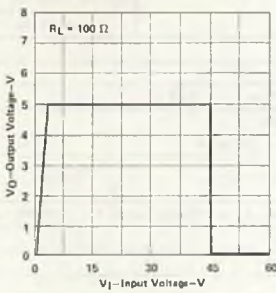


FIGURE 4

LM2930-5
OUTPUT VOLTAGE
VS
INPUT VOLTAGE

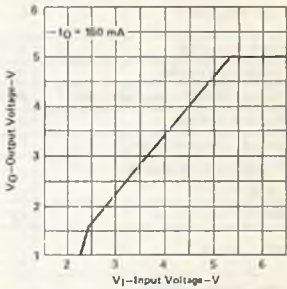


FIGURE 5

RIPPLE REJECTION
VS
FREQUENCY

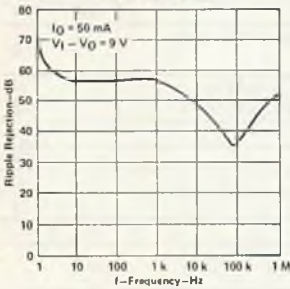


FIGURE 6

RIPPLE REJECTION
VS
OUTPUT CURRENT

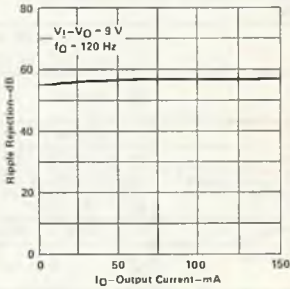


FIGURE 7

DROPOUT VOLTAGE
VS
VIRTUAL JUNCTION TEMPERATURE

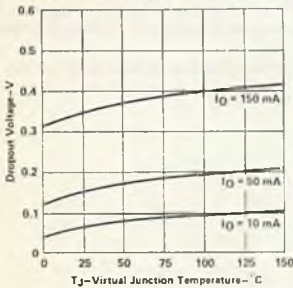


FIGURE 8

DROPOUT VOLTAGE
VS
OUTPUT CURRENT

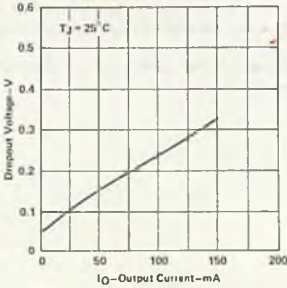


FIGURE 9

OUTPUT IMPEDANCE
VS
FREQUENCY

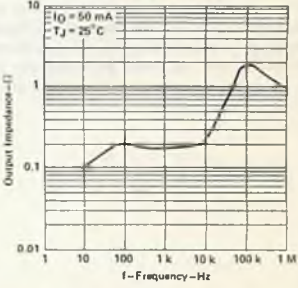


FIGURE 10

TYPICAL CHARACTERISTICS

INPUT CURRENT

VS
INPUT VOLTAGE

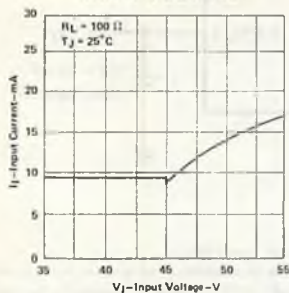


FIGURE 11

LINE TRANSIENT RESPONSE

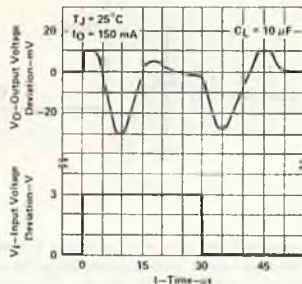


FIGURE 12

INPUT CURRENT

VS
REVERSE INPUT VOLTAGE

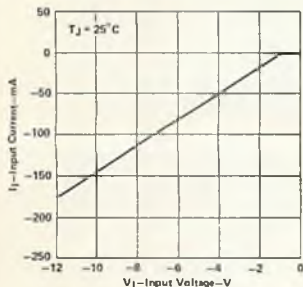


FIGURE 13

OUTPUT VOLTAGE

VS
REVERSE INPUT VOLTAGE

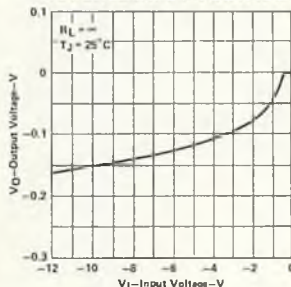


FIGURE 14

LOAD TRANSIENT RESPONSE

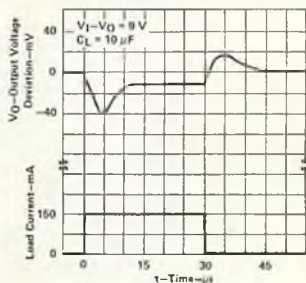


FIGURE 15
LM2905-5

BIAS CURRENT

VS
OUTPUT CURRENT

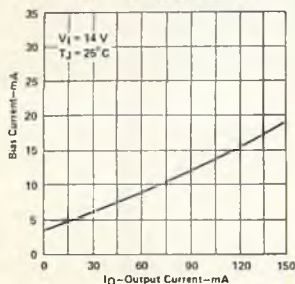


FIGURE 16

BIAS CURRENT

VS
VIRTUAL JUNCTION TEMPERATURE

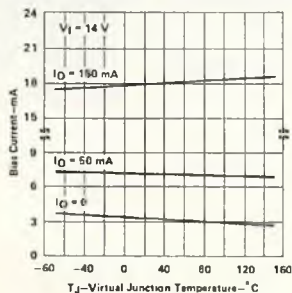


FIGURE 17

VS
INPUT VOLTAGE

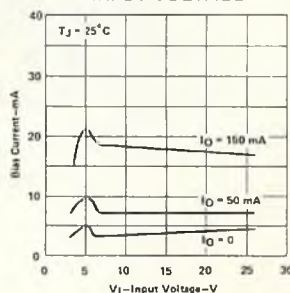


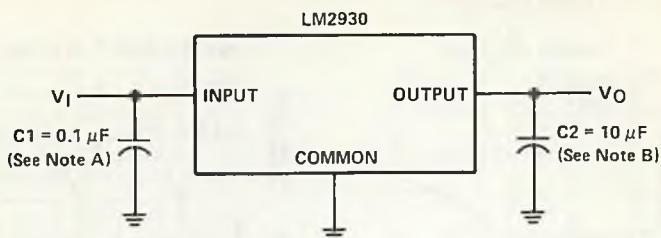
FIGURE 18

2

TYPES LM2930-5, LM2930-8

3-TERMINAL POSITIVE REGULATORS

TYPICAL APPLICATION DATA



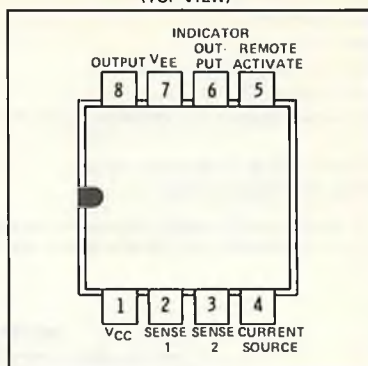
NOTES: A. Use of $C1$ is required if the regulator is not located in close proximity to the supply filter.

B. Capacitor $C2$ must be located as close as possible to the regulator and may be an aluminum or tantalum type capacitor. The minimum value required for stability is $10 \mu F$. The capacitor must be rated for operation at $-40^\circ C$ to guarantee stability to that extreme.

FIGURE 19

- **Separate Outputs for “Crowbar” and Logic Circuitry**
- **Programmable Time Delay to Eliminate Noise Triggering**
- **TTL-Level Activation Isolated from Voltage-Sensing Inputs**
- **2.6-Volt Internal Voltage Reference with Temperature Coefficient Typically 0.08%/°C**

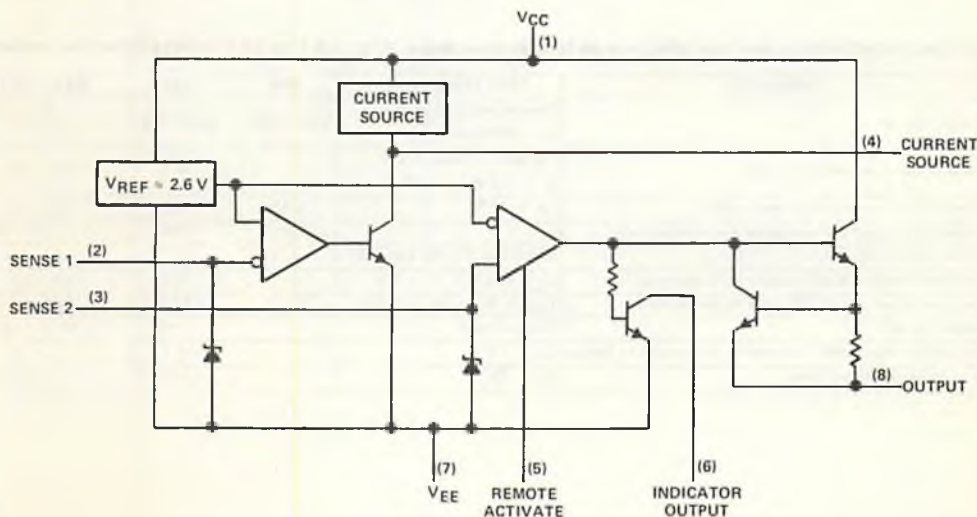
MC3423 JG OR P
DUAL-IN-LINE PACKAGE
(TOP VIEW)

**description**

The MC3423 overvoltage-sensing circuit is designed to protect sensitive electronic circuitry by monitoring the supply rail and triggering an external "crowbar" SCR in the event of a voltage transient or loss of regulation. The protective mechanism may be activated by an overvoltage condition at the Sense 2 input or by application of a TTL high level to the Remote Activate terminal. Separate outputs are available to trigger the crowbar circuit and to provide a logic pulse to indicator or power supply control circuitry. The Sense 2 input provides a direct control of the output circuitry. The Sense 1 input controls an internal current source that may be utilized to implement a delayed trigger by connecting its output to an external capacitor and the Sense 2 input. This protects against false triggering due to noise at the Sense 1 input.

The MC3423 is characterized for operation from 0°C to 70°C.

functional block diagram



TYPE MC3423

OVERVOLTAGE-SENSING CIRCUIT

absolute maximum ratings

Supply voltage, V_{CC} (see Note 1)	40 V
Sense 1 voltage	6.5 V
Sense 2 voltage	6.5 V
Remote activate input voltage	7 V
Output current, I_O	300 mA
Continuous dissipation at (or below) 25°C free-air temperature (see Note 2): JG package	825 mW
P package	1000 mW
Operating free-air temperature range	0°C to 70°C
Storage temperature range	-65°C to 150°C

- NOTES: 1. Voltage values are measured with respect to the V_{EE} terminal.
 2. For operating above 25°C free-air temperature, refer to the Dissipation Derating Table. In the JG package, MC3423 chips are glass-mounted.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE T_A
JG (Glass-Mounted Chip)	825 mW	6.6 mW/°C	25°C
P	1000 mW	8 mW/°C	25°C

recommended operating conditions

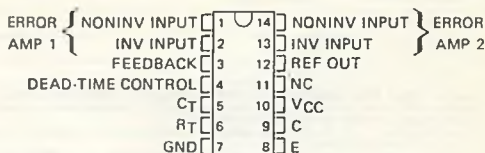
	MIN	MAX	UNIT
Supply voltage, V_{CC}	4.5	40	V
High-level input voltage, remote activate input	2		V
Low-level input voltage, remote activate input		0.5	V

electrical characteristics over operating free-air temperature range, $V_{CC} = 5$ V to 36 V (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output voltage	Remote Activate at 2 V, $I_O = 100$ mA	$V_{CC} - 2.2$	$V_{CC} - 1.8$		V
Indicator low-level output voltage	Remote Activate at 2 V, $I_O = 1.6$ mA		0.1	0.4	V
Threshold voltage of either sense input	$T_A = 25^\circ\text{C}$	2.45	2.6	2.75	V
Temperature coefficient of input threshold voltage			0.06		%/°C
Source current (pin 4)	Sense 1 at 3 V, Pin 4 at 1.3 V	0.1	0.22	0.3	mA
High-level input current, Remote Activate input	$V_{CC} = 5$ V, $V_I = 2$ V		5	40	μA
Low-level input current, Remote Activate input	$T_{CC} = 5$ V, $V_I = 0.8$ V		-120	-180	μA
Supply current	Outputs open		6	10	mA
Propagation delay time, Remote Activate input to Output	$T_A = 25^\circ\text{C}$		0.5		μs
Output current rate of rise	$T_A = 25^\circ\text{C}$		400		mA/ μs

- Complete PWM Power Control Circuitry
- Uncommitted Output for 200-mA Sink or Source Current
- Variable Dead-Time Provides Control Over Total Range
- Internal Regulator Provides a Stable 5-V Reference Supply
- Circuit Architecture Provides Easy Synchronization
- Direct Replacements for Motorola MC35060 and MC34060

J OR N
DUAL-IN-LINE PACKAGE
(TOP VIEW)



NC—No internal connections

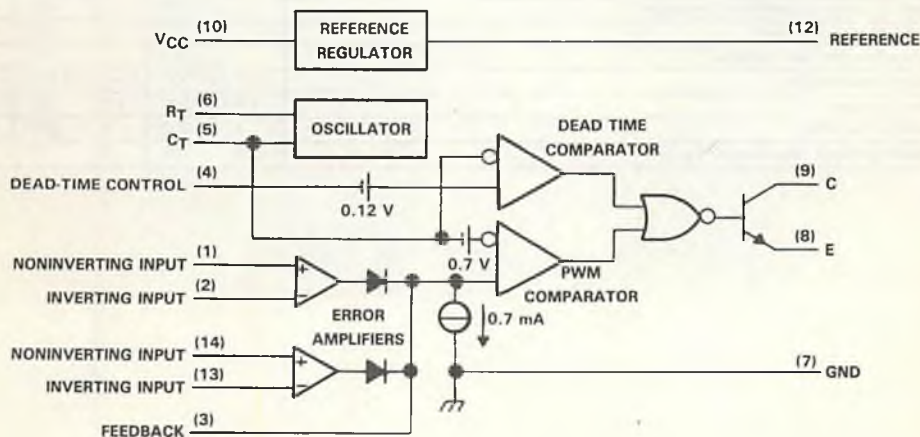
description

The MC35060 and MC34060 incorporate on a single monolithic chip all the functions required in the construction of a pulse-width-modulation control circuit. Designed primarily for power supply control, each of the devices contains an on-chip 5-volt regulator, two error amplifiers, an adjustable oscillator, and a dead-time control comparator. The uncommitted output transistor provides either common-emitter or emitter-follower output capability. The internal amplifiers exhibit a common-mode voltage range from -0.3 volt to $V_{CC} - 2$ volts. The dead-time control comparator has a fixed offset that provides approximately 5% dead time unless externally altered. The on-chip oscillator may be bypassed by terminating R_T (pin 6) to the reference output and providing a sawtooth input to C_T (pin 5), or it may be used to drive the common MC35060 or MC34060 circuitry and provide a sawtooth input for associated control circuitry in multiple rail power supplies.

The MC35060 is characterized for operation over the full military temperature range of -55°C to 125°C . The MC34060 is characterized for operation from 0°C to 70°C .

2

functional block diagram



All voltage and current values shown are nominal.

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TEXAS INSTRUMENTS
INCORPORATED

POST OFFICE BOX 225012 • DALLAS, TEXAS 75265

TYPES MC35060, MC34060

PULSE-WIDTH-MODULATION CONTROL CIRCUITS

absolute maximum ratings over operation temperature range (unless otherwise noted)

	MC35060	MC34060	UNIT
Supply voltage, V_{CC} (see Note 1)	42	42	V
Amplifier input voltages	$V_{CC} + 0.3$	$V_{CC} + 0.3$	V
Collector output voltage	42	42	V
Collector output current	250	250	mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 2)	1000	1000	mW
Operating free-air temperature range	-55 to 125	0 to 70	°C
Storage temperature range	-65 to 150	-65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package	300	300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: N package		260	°C

- NOTES: 1. All voltage values, except differential voltages, are with respect to the network ground terminal.
2. For operation above 25°C free-air temperature, refer to Dissipation Derating Table. In the J package, MC35060 chips are alloy-mounted and MC34060 chips are glass-mounted.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE T_A
J (Alloy-Mounted Chip)	1000 mW	11.0 mW/°C	59°C
J (Glass-Mounted Chip)	1000 mW	8.2 mW/°C	28°C
N	1000 mW	9.2 mW	41°C

2 recommended operating conditions

	MC35060		MC34060		UNIT
	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	7	40	7	40	V
Amplifier input voltages, V_I	-0.3	$V_{CC} - 2$	-0.3	$V_{CC} - 2$	V
Collector output voltage, V_O		40		40	V
Collector output current (each transistor)		200		200	mA
Reference output current		10		10	mA
Current into feedback terminal		0.3		0.3	mA
Timing capacitor, C_T	0.47	10 000	0.47	10 000	nF
Timing resistor, R_T	1.8	500	1.8	500	kΩ
Oscillator frequency	1	200	1	200	kHz
Operating free-air temperature, T_A	-55	125	0	70	°C

TYPES MC35060, MC34060

PULSE-WIDTH-MODULATION CONTROL CIRCUITS

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 15\text{ V}$, $f = 10\text{ kHz}$ (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS [†]	MC35060			MC34060			UNIT
		MIN	TYP [‡]	MAX	MIN	TYP [‡]	MAX	
Output voltage (V_{ref})	$I_Q = 1\text{ mA}$	4.75	5	5.25	4.75	5	5.25	V
Input regulation	$V_{CC} = 7\text{ V to }40\text{ V}$, $T_A = 25^\circ\text{C}$		2	25		2	25	mV
Output regulation	$I_Q = 1\text{ to }10\text{ mA}$, $T_A = 25^\circ\text{C}$		1	15		1	15	mV
Output voltage change with temperature	$\Delta T_A = \text{MIN to MAX}$		0.2	2		0.2	2.6	%
Short-circuit output current [§]	$V_{ref} = 0$	10	35	50		35		mA

oscillator section

PARAMETER	TEST CONDITIONS [†]	MC35060			MC34060			UNIT
		MIN	TYP [‡]	MAX	MIN	TYP [‡]	MAX	
Frequency	$C_T = 0.001\text{ }\mu\text{F}$, $R_T = 47\text{ k}\Omega$		25			25		kHz
Standard deviation of frequency [¶]	$C_T = 0.001\text{ }\mu\text{F}$, $R_T = 47\text{ k}\Omega$		3			3		%
Frequency change with voltage	$V_{CC} = 7\text{ V to }40\text{ V}$, $T_A = 25^\circ\text{C}$		0.1			0.1		%
Frequency change with temperature	$C_T = 0.001\text{ }\mu\text{F}$, $R_T = 47\text{ k}\Omega$ $\Delta T_A = \text{MIN to MAX}$			4			2	%

dead-time control-section (see figure 1)

PARAMETER	TEST CONDITIONS		MIN	TYP [†]	MAX	UNIT
Input bias current (pin 4)	$V_I = 0\text{ to }5.25\text{ V}$			-2	-10	μA
Maximum duty cycle	$V_I (\text{pin } 4) = 0$	$C_T = 0.1\text{ }\mu\text{F}$, $R_T = 12\text{ k}\Omega$	90	96	100	%
		$C_T = 0.1\text{ }\mu\text{F}$, $R_T = 47\text{ k}\Omega$		92	100	
Input threshold voltage (pin 4)	Zero duty cycle			3	3.3	V
	Maximum duty cycle		0			

error-amplifier sections

PARAMETER	TEST CONDITIONS	MIN	TYP [†]	MAX	UNIT
Input offset voltage	$V_O (\text{pin } 3) = 2.5\text{ V}$		2	10	mV
Input offset current	$V_O (\text{pin } 3) = 2.5\text{ V}$		25	250	nA
Input bias current	$V_O (\text{pin } 3) = 2.5\text{ V}$		0.2	1	μA
Common-mode input voltage range	$V_{CC} = 7\text{ V to }40\text{ V}$	-0.3 to $V_{CC} - 2$			V
Open-loop voltage amplification	$\Delta V_O = 3\text{ V}$, $R_L = 2\text{ k}\Omega$, $V_O = 0.5\text{ V to }3.5\text{ V}$	70	95		dB
Unit-gain bandwidth			800		kHz
Common-mode rejection ratio	$V_{CC} = 40\text{ V}$	65	80		dB
Output sink current (pin 3)	$V_{ID} = -15\text{ mV to }-5\text{ V}$, $V_{(\text{pin } 3)} = 0.5\text{ V}$	0.3	0.7		mA
Output source current (pin 3)	$V_{ID} = 15\text{ mV to }5\text{ V}$, $V_{(\text{pin } 3)} = 3.5\text{ V}$	-2			mA

output section

PARAMETER	TEST CONDITIONS	MC35060			MC34060			UNIT
		MIN	TYP [‡]	MAX	MIN	TYP [‡]	MAX	
Collector off-state current	$V_{CE} = 40\text{ V}$, $V_{CC} = 40\text{ V}$		2	100		2	100	μA
Emitter off-state current	$V_{CC} = V_C = 40\text{ V}$, $V_E = 0$			-150			-100	μA
Collector-emitter saturation voltage	$V_E = 0$, $I_C = 200\text{ mA}$	1.1	1.5		1.1	1.3		V
Emitter follower	$V_C = 15\text{ V}$, $I_E = -200\text{ mA}$	1.5	2.5		1.5	2.5		V

[†]For conditions shown as MIN or MAX, use the appropriate value specified under recommended operation conditions.

[‡]All typical values except for temperature coefficients are at $T_A = 25^\circ\text{C}$.

[§]Duration of the short-circuit should not exceed one second.

[¶]Standard deviation is a measure of the statistical distribution about the mean as derived from the formula

$$\sigma = \sqrt{\frac{N}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2}$$

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TYPES MC35060, MC34060
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 15\text{ V}$, $f = 10\text{ kHz}$ (unless otherwise noted)

pwm comparator section (see figure 1)

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Input threshold voltage (pin 3)	Zero duty cycle		4	4.5	V
Input sink current (pin 3)	$V_{(pin\ 3)} = 0.7\text{ V}$	0.3	0.7		mA

total device

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Standby supply current	Pin 6 at V_{ref} , All other inputs and outputs open		6	10	mA
			9	15	
Average supply current	$V_{(pin\ 4)} = 2\text{ V}$, See Figure 1		7.5		mA

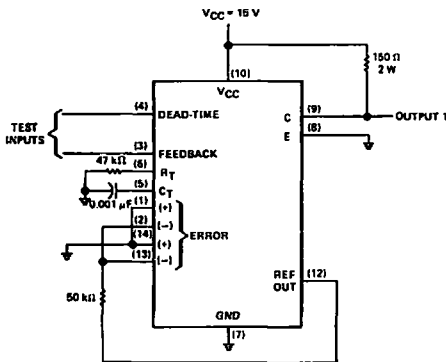
switching characteristics, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Output voltage rise time	Common-emitter configuration, See Figure 3		100	200	ns
Output voltage fall time			25	100	
Output voltage rise time	Emitter-follower configuration, See Figure 4		100	200	ns
Output voltage fall time			40	100	

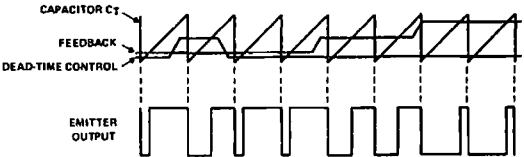
†All typical values except for temperature coefficients are at $T_A = 25^\circ\text{C}$.

PARAMETER MEASUREMENT INFORMATION

2



TEST CIRCUIT



TIMING WAVEFORMS

FIGURE 1 — DEAD-TIME AND FEEDBACK CONTROL

PARAMETER MEASUREMENT INFORMATION

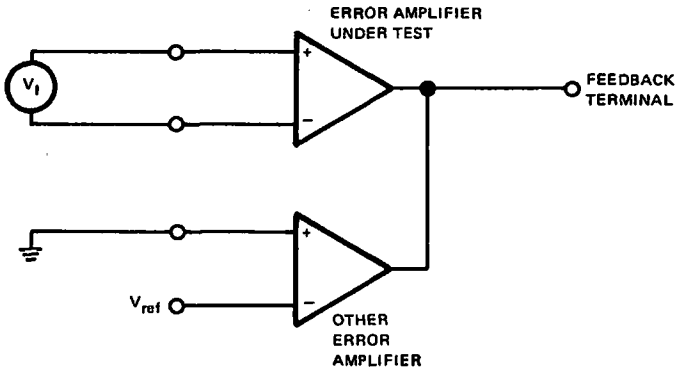


FIGURE 2 — ERROR-AMPLIFIER CHARACTERISTICS

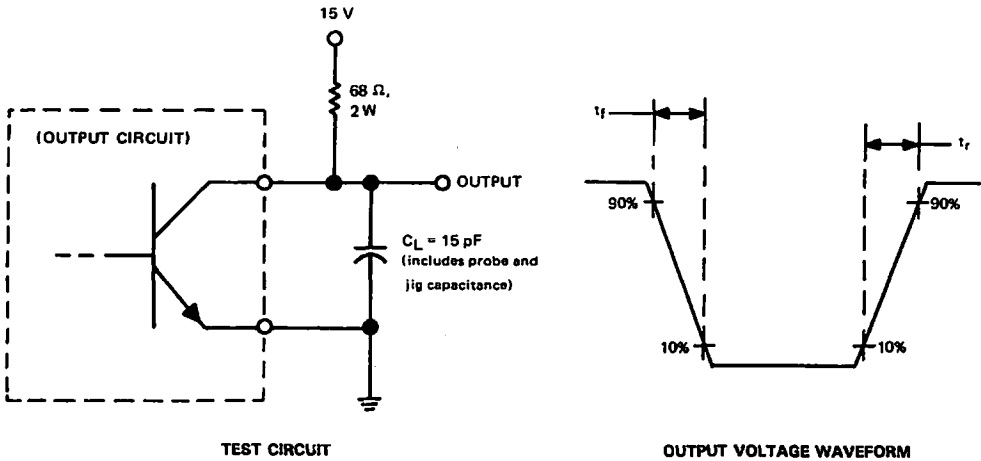


FIGURE 3 — COMMON-EMITTER CONFIGURATION

TYPES MC35060, MC34060 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

PARAMETER MEASUREMENT INFORMATION

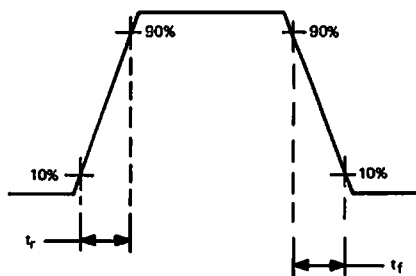
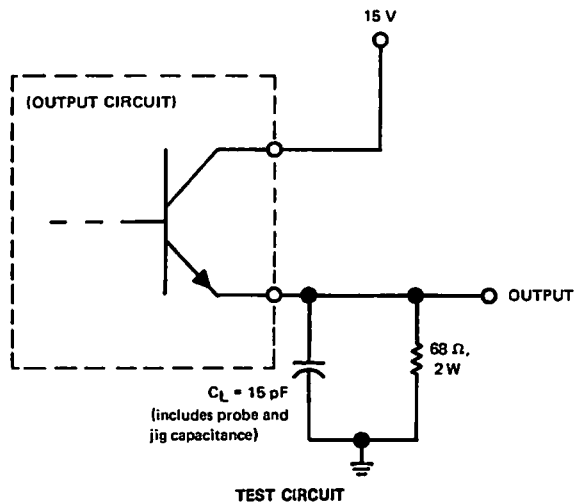


FIGURE 4 — EMITTER-FOLLOWER CONFIGURATION

2

TYPICAL CHARACTERISTICS

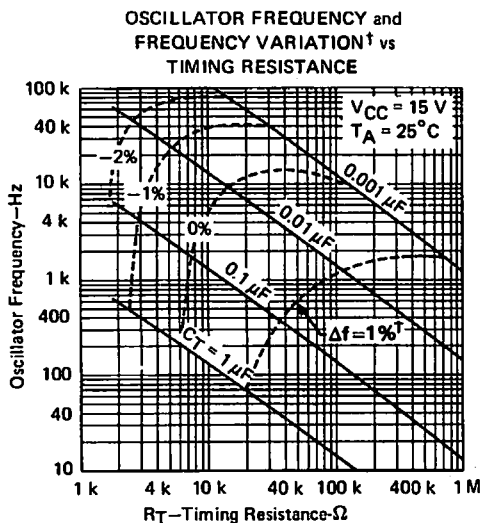


FIGURE 5

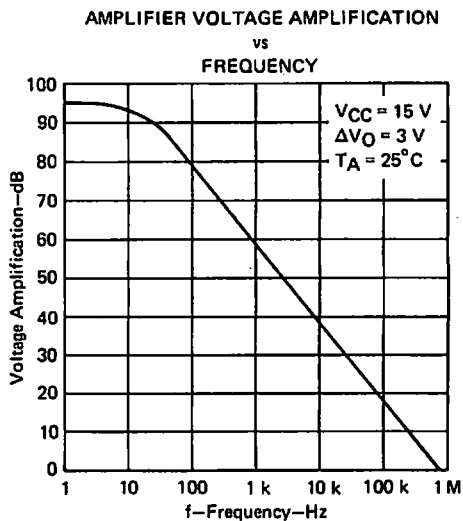


FIGURE 6

[†]Frequency variation (Δf) is the change in oscillator frequency that occurs over the full temperature range.

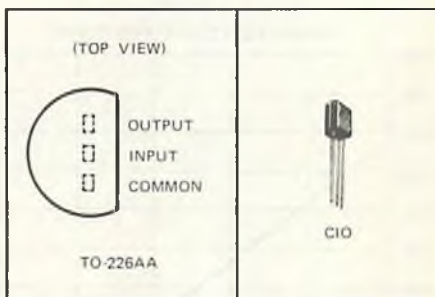
- 3-Terminal Regulators
- Output Current up to 100 mA
- No External Components Required
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting
- Direct Replacement for Motorola MC79L00 Series
- Available in 5% or 10% Selections

NOMINAL OUTPUT VOLTAGE	5% OUTPUT VOLTAGE TOLERANCE	10% OUTPUT VOLTAGE TOLERANCE
-5 V	MC79L05AC	MC79L05C
-12 V	MC79L12AC	MC79L12C
-15 V	MC79L15AC	MC79L15C

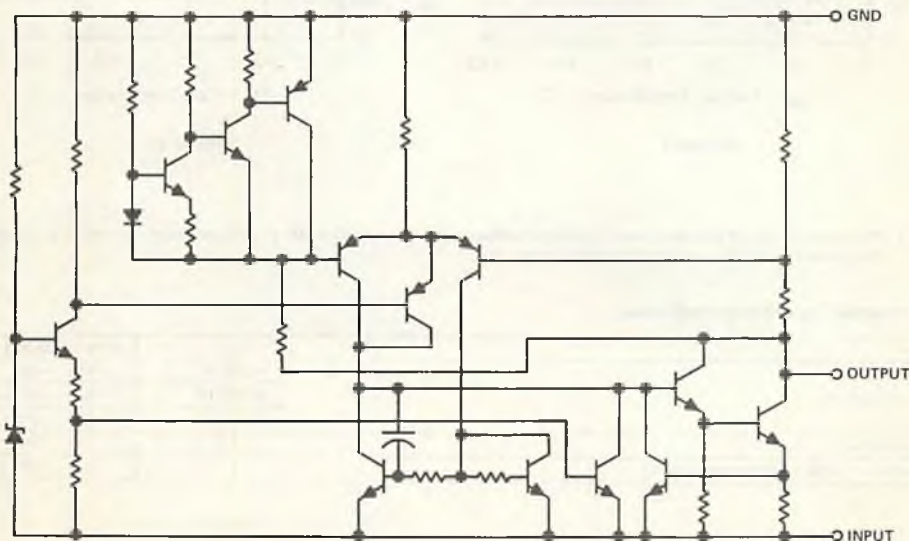
description

This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. In addition, they can be used to control series pass elements to make high-current voltage-regulator circuits. One of these regulators can deliver up to 100 mA of output current. The internal current-limiting and thermal-shutdown features make them essentially immune to overload. When used as a replacement for a Zener-diode and resistor combination, these devices can provide an effective improvement in output impedance of two orders of magnitude and lower bias current.

LP SILECT[†] PACKAGE



schematic



[†]Trademark of Texas Instruments Incorporated.

SERIES MC79L00

NEGATIVE-VOLTAGE REGULATORS

absolute maximum ratings over operating temperature range (unless otherwise noted)

	MC79L05	MC79L12 MC79L15	UNIT
Input voltage	-30	-35	V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	775	775	mW
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	1600	1600	mW
Operating free-air, case, or virtual junction temperature range	0 to 150	0 to 150	°C
Storage temperature range	-65 to 150	-65 to 150	°C
Lead temperature 1/16 inch (1.6 mm) from case for 10 seconds	260	260	°C

NOTE 1: For operation above 25°C free-air temperature, refer to Dissipation Derating Curves, Figure 1 and Figure 2.

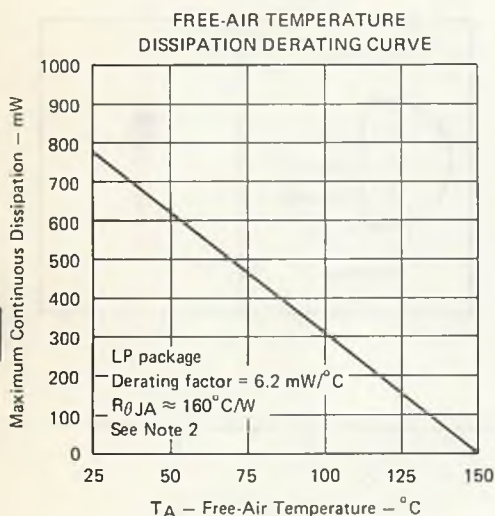


FIGURE 1

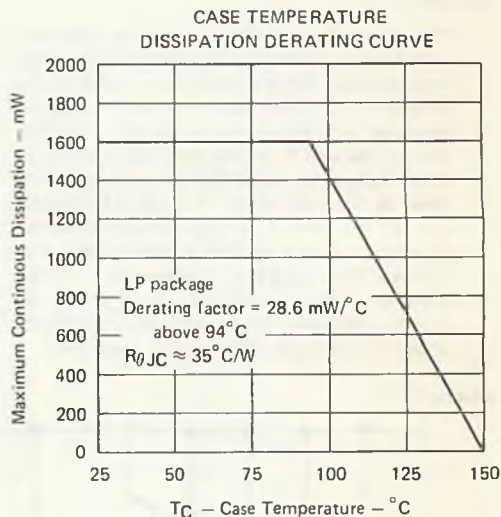


FIGURE 2

NOTE 2: This curve for the LP package is based on thermal resistance, $R_{\theta JA}$, measured in still air with the device mounted in an Augat socket. The bottom of the package was 3/8 inch above the socket.

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	MC79L05	-7	-20	V
	MC79L12	-14.5	-27	
	MC79L15	-17.5	-30	
Output current, I_O			100	mA
Operating virtual junction temperature, T_J		0	125	°C

SERIES MC79L00

NEGATIVE-VOLTAGE REGULATORS

MC79L05 electrical characteristics at specified virtual junction temperature,
 $V_I = -10\text{ V}$, $I_O = 40\text{ mA}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MC79L05C			MC79L05AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage		25°C	-4.6	-5	-5.4	-4.8	-5	-5.2	V
	$V_I = -7\text{ V to }-20\text{ V}$, $I_O = 1\text{ mA to }40\text{ mA}$	0°C to 125°C	-4.5		-5.5	-4.75		-5.25	
	$V_I = -10\text{ V}$, $I_O = 1\text{ mA to }70\text{ mA}$	0°C to 125°C	-4.5		-5.5	-4.75		-5.25	
Input regulation	$V_I = -7\text{ V to }-20\text{ V}$	25°C			200			150	mV
	$V_I = -8\text{ V to }-20\text{ V}$				150			100	
Ripple rejection	$V_I = -8\text{ V to }-18\text{ V}$, $f = 120\text{ Hz}$	25°C	40	49		41	49		dB
Output regulation	$I_O = 1\text{ mA to }100\text{ mA}$	25°C			60			60	mV
	$I_O = 1\text{ mA to }40\text{ mA}$				30			30	
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C		40			40		μV
Dropout voltage	$I_O = 40\text{ mA}$	25°C		1.7			1.7		V
Bias current		25°C			6			6	mA
		125°C			5.5			5.5	
Bias current change	$V_I = -8\text{ V to }-20\text{ V}$	0°C to 125°C			1.5			1.5	mA
	$I_O = 1\text{ mA to }40\text{ mA}$				0.2			0.1	

MC79L12 electrical characteristics at specified virtual junction temperature,
 $V_I = -19\text{ V}$, $I_O = 40\text{ mA}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MC79L12C			MC79L12AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage		25°C	-11.1	-12	-12.9	-11.5	-12	-12.5	V
	$V_I = -14.5\text{ to }-27\text{ V}$, $I_O = 1\text{ mA to }40\text{ mA}$	0°C to 125°C	-10.8		-13.2	-11.4		-12.6	
	$V_I = -19\text{ V}$, $I_O = 1\text{ mA to }70\text{ mA}$	0°C to 125°C	-10.8		-13.2	-11.4		-12.6	
Input regulation	$V_I = -14.5\text{ to }-27\text{ V}$	25°C			250			250	mV
	$V_I = -16\text{ V to }-27\text{ V}$				200			200	
Ripple rejection	$V_I = -15\text{ V to }-25\text{ V}$, $f = 120\text{ Hz}$	25°C	36	42		37	42		dB
Output regulation	$I_O = 1\text{ mA to }100\text{ mA}$	25°C			100			100	mV
	$I_O = 1\text{ mA to }40\text{ mA}$				50			50	
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C		80			80		μV
Dropout voltage	$I_O = 40\text{ mA}$	25°C		1.7			1.7		V
Bias current		25°C			6.5			6.5	mA
		125°C			6			6	
Bias current change	$V_I = -16\text{ V to }-27\text{ V}$	0°C to 125°C			1.5			1.5	mA
	$I_O = 1\text{ mA to }40\text{ mA}$				0.2			0.1	

† All characteristics are measured with a 0.33 μF capacitor across the input and a 0.1 μF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_W < 10\text{ ms}$, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

SERIES MC79L00

NEGATIVE-VOLTAGE REGULATORS

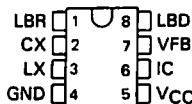
MC79L15 electrical characteristics at specified virtual junction temperature,
 $V_I = -23\text{ V}$, $I_O = 40\text{ mA}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MC79L15C			MC79L15AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage		25°C	-13.8	-15	-16.2	-14.4	-15	-15.6	V
	V _I = -17.5 V to -30 V, I _O = 1 mA to 40 mA	0°C to 125°C	-13.5		-16.5	-14.25		-15.75	
	V _I = -23 V, I _O = 1 mA to 70 mA	0°C to 125°C	-13.5		-16.5	-14.25		-15.75	
Input regulation	V _I = -17.5 V to -30 V	25°C			300			300	mV
	V _I = -20 V to -30 V				250			250	
Ripple rejection	V _I = -18.5 V to -28.5 V, f = 120 Hz	25°C	33	39		34	39		dB
Output regulation	I _O = 1 mA to 100 mA	25°C			150			150	mV
	I _O = 1 mA to 40 mA				75			75	
Output noise voltage	f = 10 Hz to 100 kHz	25°C			90			90	μV
Dropout voltage	I _O = 40 mA	25°C			1.7			1.7	V
Bias current		25°C			6.5			6.5	mA
		125°C			6			6	
Bias current change	V _I = -20 V to -30 V	0°C to 125°C			1.5			1.5	mA
	I _O = 1 mA to 40 mA				0.2			0.1	

† All characteristics are measured with a $0.33\text{ }\mu\text{F}$ capacitor across the input and a $0.1\text{ }\mu\text{F}$ capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10\text{ ms}$, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

- High Efficiency . . . 80% Typ
- Low Bias Current . . . 135 μ A
- Adjustable Output . . . 2.5 V to 24 V
- Output Current . . . 150 mA
- Internal Reference . . . 1.3 V \pm 5%
- Remote Shutdown Capabilities
- Interchangeable with Raytheon RC4193

RC4193M . . . JG
RC4193I, RC4193C . . . JG OR P
DUAL-IN-LINE PACKAGE
(TOP VIEW)



FUNCTION TABLE

PIN	FUNCTION	DESCRIPTION
1	LBR	Low battery resistor
2	CX	External capacitor
3	LX	External inductor
4	GND	Ground
5	VCC	Supply voltage
6	IC	Reference set control
7	VFB	Feedback voltage
8	LBD	Low battery detector

description

The RC4193 is a monolithic micropower switching regulator designed to provide all the functions required to make a complete low-power switching regulator primarily for battery operated instruments. The RC4193 offers the system designer the flexibility of tailoring the circuit to the application. Typical applications include step-up switching regulation, step-down switching regulation, and inverting switch regulation. The RC4193 contains a 1.3-volt temperature-compensated band-gap reference, an adjustable free-running oscillator, voltage comparator, low battery detection circuitry, and a 150-milliampere output-switch transistor.

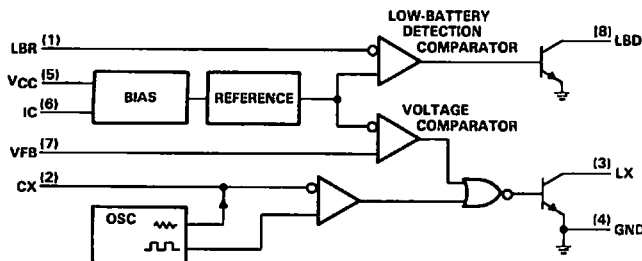
For most applications, the RC4193 can achieve up to 80% efficiency while operating over a wide supply voltage range from 2.4 volts to 24 volts at an ultra-low bias current drain of 135 microamperes. The RC4193 has an adjustable 100-hertz to 180-kilohertz free-running oscillator that provides the drive circuitry for the on-chip 150-milliampere output-switch transistor. An external capacitor on pin 2 determines the oscillator frequency.

The low-battery detection circuitry contains an open-collector output transistor that can be used to activate a liquid crystal display whenever the battery voltage drops below a programmed level. This programmed level is determined by the selection of external resistors connected to pin 1.

The RC4193 will shut off when pin 6 (IC) is below 0.5 volt. The shut-off feature is useful in battery-backup applications requiring operation only when the line power is removed. Another use of this feature is connecting a zener diode between pin 6 and the battery line to shut down the regulator whenever the battery voltage drops below a predetermined level.

The RC4193M is characterized for operation over the full military temperature range of -55°C to 125°C . The RC4193I is characterized for operation from -25°C to 85°C . The RC4193C is characterized for operation from 0°C to 70°C .

functional block diagram



PRODUCT PREVIEW

This document contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.

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LINEAR INTEGRATED CIRCUITS REGULATING PULSE WIDTH MODULATORS

TYPES SG1524, SG2524, SG3524

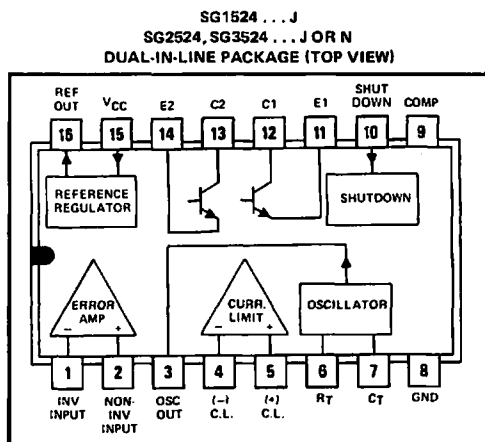
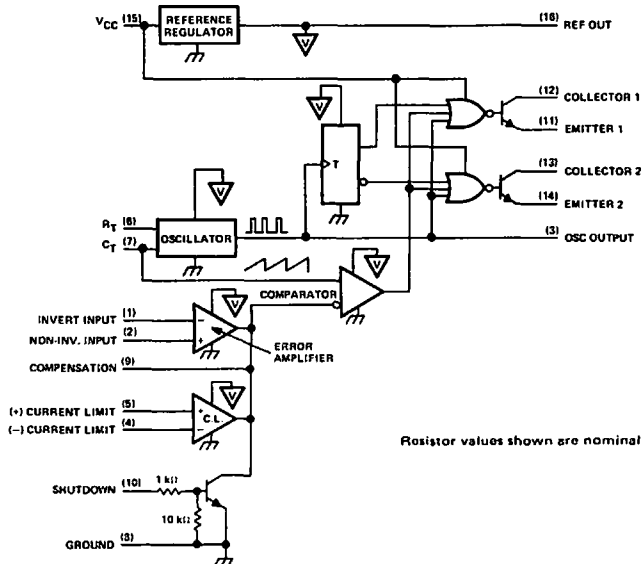
D2294, APRIL 1977 — REVISED DECEMBER 1982

- Complete PWM Power Control Circuitry
- Uncommitted Outputs for Single-Ended or Push-Pull Applications
- Low Standby Current . . . 8 mA Typ
- Interchangeable With Silicon General SG1524, SG2524, and SG3524

description

The SG1524, SG2524, and SG3524 incorporate on single monolithic chips all the functions required in the construction of a regulating power supply, inverter, or switching regulator. They can also be used as the control element for high-power-output applications. The SG1524 family was designed for switching regulators of either polarity, transformer-coupled dc-to-dc converters, transformerless voltage doublers, and polarity converter applications employing fixed-frequency, pulse-width-modulation techniques. The complementary output allows either single-ended or push-pull application. Each device includes an on-chip regulator, error amplifier, programmable oscillator, pulse-steering flip-flop, two uncommitted pass transistors, a high-gain comparator, and current-limiting and shut-down circuitry.

functional block diagram



The SG1524 is characterized for operation over the full military temperature range of -55°C to 125°C . The SG2524 is characterized for operation from -25°C to 85°C , and the SG3524 is characterized for operation from 0°C to 70°C .

2

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TEXAS INSTRUMENTS
INCORPORATED

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2-65

TYPES SG1524, SG2524, SG3524

REGULATING PULSE WIDTH MODULATORS

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply Voltage, V_{CC} (see Notes 1 and 2)	40 V
Collector Output Current	100 mA
Reference Output Current	50 mA
Current Through C_T Terminal	—5 mA
Continuous Total Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	1000 mW
Operating Free-Air Temperature Range: SG1524	—55°C to 125°C
SG2524	—25°C to 85°C
SG3524	0°C to 70°C
Storage Temperature Range	—65°C to 150°C

NOTES: 1. All voltage values are with respect to network ground terminal.

2. The reference regulator may be bypassed for operation from a fixed 5-volt supply by connecting the V_{CC} and reference output pins both to the supply voltage. In this configuration the maximum supply voltage is 6 volts.

3. For operation at elevated temperature, refer to Figures 16 and 17. In the J package, SG1524 chips are alloy-mounted; SG2524 and SG3524 chips are glass-mounted.

recommended operating conditions

	SG1524		SG2524		SG3524		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	8	40	8	40	8	40	V
Reference output current	0	50	0	50	0	50	mA
Current thru C_T terminal	—0.03	—2	—0.03	—2	—0.03	—2	mA
Timing resistor, R_T	1.8	100	1.8	100	1.8	100	k Ω
Timing capacitor, C_T	0.001	0.1	0.001	0.1	0.001	0.1	μ F
Operating free-air temperature	—55	125	—25	85	0	70	°C

2

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 20$ V, $f = 20$ kHz (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS†	SG1524			SG2524			SG3524			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Output voltage		4.8	5	5.2	4.8	5	5.2	4.8	5	5.4	V
Input regulation	$V_{CC} = 8$ to 40 V		10	20		10	20		10	30	mV
Ripple rejection	$f = 120$ Hz		66			66			66		dB
Output regulation	$I_O = 0$ to 20 mA		20	50		20	50		20	50	mV
Output voltage change with temperature	$T_A = \text{MIN to MAX}$		0.6	2		0.3	1		0.3	1	%
Short-circuit output current §	$V_{ref} = 0$		100			100			100		mA

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡ All typical values except output voltage change with temperature are at $T_A = 25^\circ\text{C}$.

§ Duration of the short-circuit should not exceed one second.

TYPES SG1524, SG2524, SG3524 REGULATING PULSE WIDTH MODDLATORS

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 20\text{ V}$, $f = 20\text{ kHz}$
(unless otherwise noted)

oscillator section

PARAMETER	TEST CONDITIONS†	MIN	TYP‡	MAX	UNIT
Frequency	$C_T = 0.001\text{ }\mu\text{F}$, $R_T = 2\text{ k}\Omega$		450		kHz
Standard deviation of frequency §	All values of voltage, temperature, resistance, and capacitance constant		5		%
Frequency change with voltage	$V_{CC} = 8\text{ to }40\text{ V}$, $T_A = 25^\circ\text{C}$			1	%
Frequency change with temperature	$T_A = \text{MIN to MAX}$			2	%
Output amplitude at pin 3			3.5		V
Output pulse width at pin 3	$C_T = 0.01\text{ }\mu\text{F}$		0.5		μs

error amplifier section

PARAMETER	TEST CONDITIONS	SG1524, SG2524		SG3524		UNIT		
		MIN	TYP‡	MAX	MIN		TYP‡	MAX
Input offset voltage	V _{IC} = 2.5 V		0.5	5		2	10	mV
Input bias current	V _{IC} = 2.5 V		2	10		2	10	μA
Open-loop voltage amplification		72	80		60	80		dB
Common-mode input voltage range	T _A = 25°C	1.8 to 3.4			1.8 to 3.4			V
Common-mode rejection ratio			70			70		dB
Unity-gain bandwidth			3			3		MHz
Output swing	T _A = 25°C	0.5		3.8	0.5		3.8	V

2

output section

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Collector-emitter breakdown voltage		40			V
Collector off-state current	$V_{CE} = 40\text{ V}$		0.01	50	μA
Collector-emitter saturation voltage	$I_C = 50\text{ mA}$		1	2	V
Emitter output voltage	$V_C = 20\text{ V}$, $I_E = -250\text{ }\mu\text{A}$	17	18		V
Turn-off voltage rise time	$R_C = 2\text{ k}\Omega$		0.2		μs
Turn-on voltage fall time	$R_C = 2\text{ k}\Omega$		0.1		μs

comparator section

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Maximum duty cycle, each output		45			%
Input threshold voltage at pin 9	Zero duty cycle		1		V
	Maximum duty cycle		3.5		V
Input bias current			-1		μA

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡All typical values except for temperature coefficients are at $T_A = 25^\circ\text{C}$.

§Standard deviation is a measure of the statistical distribution about the mean as derived from the formula $\sigma = \sqrt{\frac{\sum_{i=1}^N (X_i - \bar{X})^2}{N-1}}$

TEXAS INSTRUMENTS
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TYPES SG1524, SG2524, SG3524

REGULATING PULSE WIDTH MODULATORS

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 20\text{ V}$, $f = 20\text{ kHz}$ (unless otherwise noted)

current limiting section

PARAMETER	TEST CONDITIONS	SG1524, SG2524			SG3524			UNIT
		MIN	TYP [‡]	MAX	MIN	TYP [‡]	MAX	
Input voltage range (either input)		-1 to +1			-1 to +1			V
Sense voltage at $T_A = 25^\circ\text{C}$	$V(\text{pin } 2) - V(\text{pin } 1) \geq 50\text{ mV}$,	190	200	210	180	200	220	mV
Temperature coefficient of sense voltage	$V(\text{pin } 9) = 2\text{ V}$	0.2			0.2			mV/°C

total device

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Standby current	$V_{CC} = 40\text{ V}$, Pin 2 at 2 V, Pins 1,4,7,8,9,11,14 grounded, All other inputs and outputs open		8	10	mA

[‡]All typical values except for temperature coefficients are at $T_A = 25^\circ\text{C}$.

PARAMETER MEASUREMENT INFORMATION

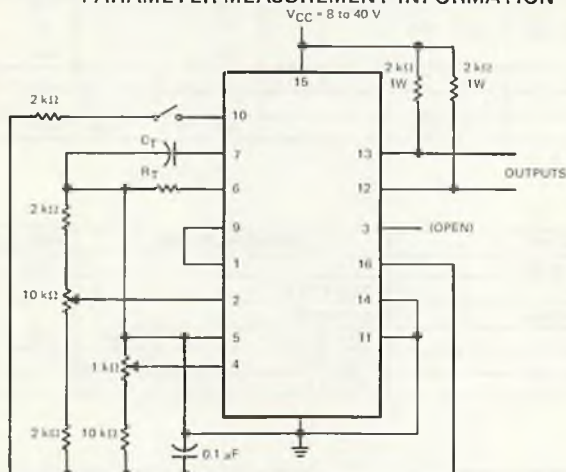


FIGURE 1—GENERAL TEST CIRCUIT

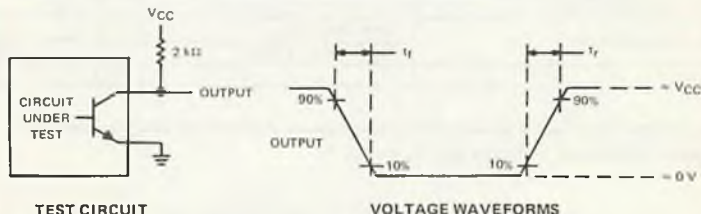
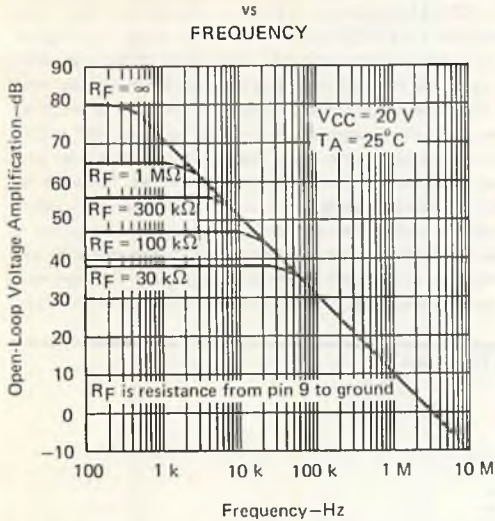


FIGURE 2—SWITCHING TIMES

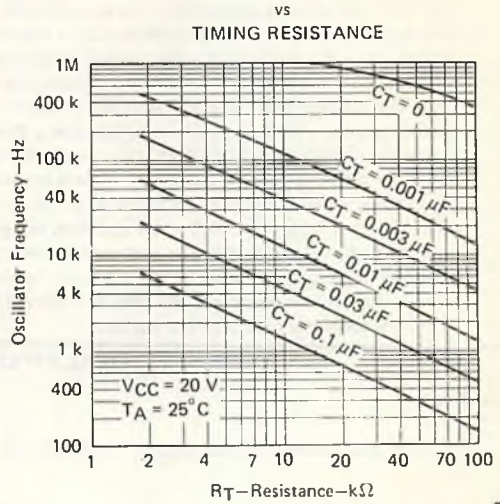
TYPES SG1524, SG2524, SG3524 REGULATING PULSE WIDTH MODULATORS

TYPICAL CHARACTERISTICS

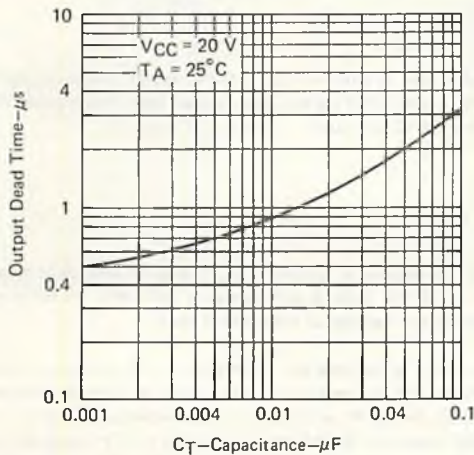
OPEN-LOOP VOLTAGE AMPLIFICATION OF ERROR AMPLIFIER



OSCILLATOR FREQUENCY



OUTPUT DEAD TIME VS TIMING CAPACITANCE VALUE



2

TYPES SG1524, SG2524, SG3524

REGULATING PULSE WIDTH MODULATORS

PRINCIPLES OF OPERATION

The SG1524[†] is a fixed-frequency pulse-width-modulation voltage-regulator control circuit. The regulator operates at a fixed frequency that is programmed by one timing resistor R_T and one timing capacitor C_T . R_T establishes a constant charging current for C_T . This results in a linear voltage ramp at C_T , which is fed to the comparator providing linear control of the output pulse width by the error amplifier. The SG1524 contains an on-board 5-volt regulator that serves as a reference as well as supplying the SG1524's internal regulator control circuitry. The internal reference voltage is divided externally by a resistor ladder network to provide a reference within the common-mode range of the error amplifier as shown in Figure 6, or an external reference may be used. The output is sensed by a second resistor divider network and the error signal is amplified. This voltage is then compared to the linear voltage ramp at C_T . The resulting modulated pulse out of the high-gain comparator is then steered to the appropriate output pass transistor (Q1 or Q2) by the pulse-steering flip-flop, which is synchronously toggled by the oscillator output. The oscillator output pulse also serves as a blanking pulse to assure both outputs are never on simultaneously during the transition times. The width of the blanking pulse is controlled by the value of C_T . The outputs may be applied in a push-pull configuration in which their frequency is half that of the base oscillator, or paralleled for single-ended applications in which the frequency is equal to that of the oscillator. The output of the error amplifier shares a common input to the comparator with the current-limiting and shut-down circuitry and can be overridden by signals from either of these inputs. This common point is also available externally and may be employed to control the gain of, or to compensate, the error amplifier, or to provide additional control to the regulator.

TYPICAL APPLICATION DATA

oscillator

The oscillator controls the frequency of the SG1524 and is programmed by R_T and C_T as shown in Figure 4.

$$f = \frac{1.15}{R_T C_T}$$

where R_T is in kilohms
 C_T is in microfarads
 f is in kilohertz

Practical values of C_T fall between 0.001 and 0.1 microfarad. Practical values of R_T fall between 1.8 and 100 kilohms. This results in a frequency range typically from 140 hertz to 500 kilohertz.

blanking

The output pulse of the oscillator is used as a blanking pulse at the output. This pulse width is controlled by the value of C_T as shown in Figure 5. If small values of C_T are required, the oscillator output pulse width may still be maintained by applying a shunt capacitance from pin 3 to ground.

synchronous operation

When an external clock is desired, a clock pulse of approximately 3 volts can be applied directly to the oscillator output terminal. The impedance to ground at this point is approximately 2 kilohms. In this configuration R_T C_T must be selected for a clock period slightly greater than that of the external clock.

If two or more SG1524 regulators are to be operated synchronously, all oscillator output terminals should be tied together. The oscillator programmed for the minimum clock period will be the master from which all the other SG1524's operate. In this application, the C_T R_T values of the slaved regulators must be set for a period approximately 10% longer than that of the master regulator. In addition, C_T (master) = 2 C_T (slave) to ensure that the master output pulse, which occurs first, has a wider pulse width and will subsequently reset the slave regulators.

[†] Throughout these discussions, references to SG1524 apply also to SG2524 and SG3524.

TYPES SG1524, SG2524, SG3524 REGULATING PULSE WIDTH MODULATORS

TYPICAL APPLICATION DATA

voltage reference

The 5-volt internal reference may be employed by use of an external resistor divider network to establish a reference within the error amplifiers common-mode voltage range (1.8 to 3.4 volts) as shown in Figure 6, or an external reference may be applied directly to the error amplifier. For operation from a fixed 5-volt supply, the internal reference may be bypassed by applying the input voltage to both the V_{CC} and V_{REF} terminals. In this configuration, however, the input voltage is limited to a maximum of 6 volts.

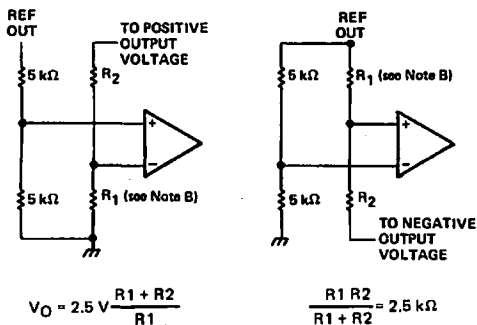


FIGURE 6—ERROR AMPLIFIER BIAS CIRCUITS

2

error amplifier

The error amplifier is a differential-input transconductance amplifier. The output is available for dc gain control or ac phase compensation. The compensation node (pin 9) is a high-impedance node ($R_L = 5$ megohms). The gain of the amplifier is $A_V = (0.002 \Omega^{-1}) R_L$ and can easily be reduced from a nominal 10,000 by an external shunt resistance from pin 9 to ground. Refer to Figure 3 for data.

compensation

Pin 9, as discussed above, is made available for compensation. Since most output filters will introduce one or more additional poles at frequencies below 200 hertz, which is the pole of the uncompensated amplifier, introduction of a zero to cancel one of the output filter poles is desirable. This can best be accomplished with a series RC circuit from pin 9 to ground in the range of 50 kilohms and 0.001 microfarads. Other frequencies can be canceled by use of the formula $f \approx 1/RC$.

shut down circuitry

Pin 9 can also be employed to introduce external control of the SG1524. Any circuit that can sink 200 microamperes can pull the compensation terminal to ground and thus disable the SG1524.

In addition to constant-current limiting, pins 4 and 5 may also be used in transformer-coupled circuits to sense primary current and shorten an output pulse should transformer saturation occur. Pin 5 may also be grounded to convert pin 4 into an additional shutdown terminal.

TYPES SG1524, SG2524, SG3524

REGULATING PULSE WIDTH MODULATORS

TYPICAL APPLICATION DATA

current limiting

A current-limiting sense amplifier is provided in the SG1524. The current-limiting sense amplifier exhibits a threshold of 200 millivolts and must be applied in the ground line since the voltage range of the inputs is limited to +1 volt to -0.7 volt. Caution should be taken to ensure the -0.7-volt limit is not exceeded by either input, otherwise damage to the device may result.

Fold-back current limiting can be provided with the network shown in Figure 7. The current-limit schematic is shown in Figure 8.

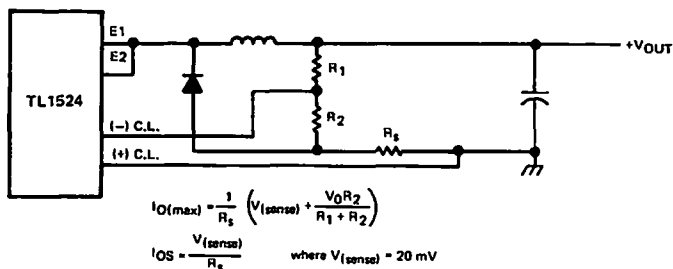


FIGURE 7—FOLDBACK CURRENT LIMITING FOR SHORTED OUTPUT CONDITIONS

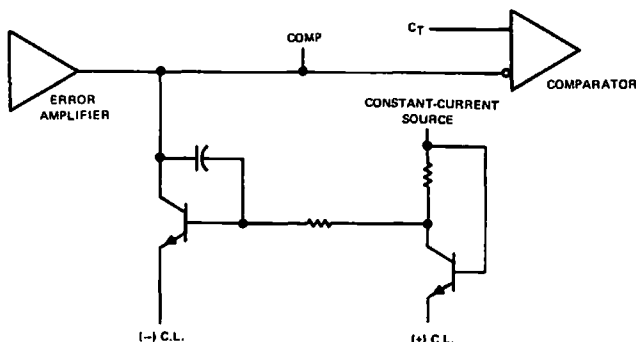


FIGURE 8—CURRENT-LIMIT SCHEMATIC

output circuitry

The SG1524 contains two identical n-p-n transistors the collectors and emitters of which are uncommitted. Each transistor has antisaturation circuitry that limits the current through that transistor to a maximum of 100 milliamperes for fast response.

TYPES SG1524, SG2524, SG3524 REGULATING PULSE WIDTH MODULATORS

TYPICAL APPLICATION DATA

general

There are a wide variety of output configurations possible when considering the application of the SG1524 as a voltage regulator control circuit. They can be segregated into three basic categories:

1. Capacitor-diode-coupled voltage multipliers
2. Inductor-capacitor-implemented single-ended circuits
3. Transformer-coupled circuits

Examples of these categories are shown in Figures 9, 10 and 11, respectively. Detailed diagrams of specific applications are shown in Figures 12 through 15.

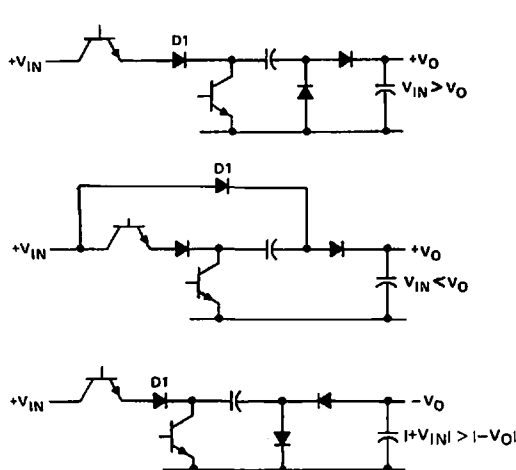


FIGURE 9—CAPACITOR-DIODE-COUPLED VOLTAGE-MULTIPLIER OUTPUT STAGES

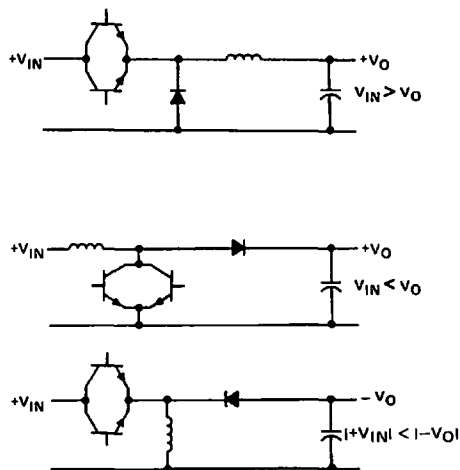
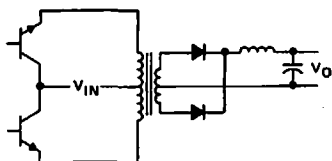
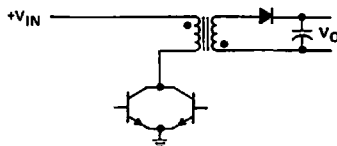


FIGURE 10—SINGLE-ENDED INDUCTOR CIRCUIT



PUSH PULL



FLYBACK

FIGURE 11—TRANSFORMER-COUPLED OUTPUTS

TYPES SG1524, SG2524, SG3524 REGULATING PULSE WIDTH MODULATORS

TYPICAL APPLICATION DATA

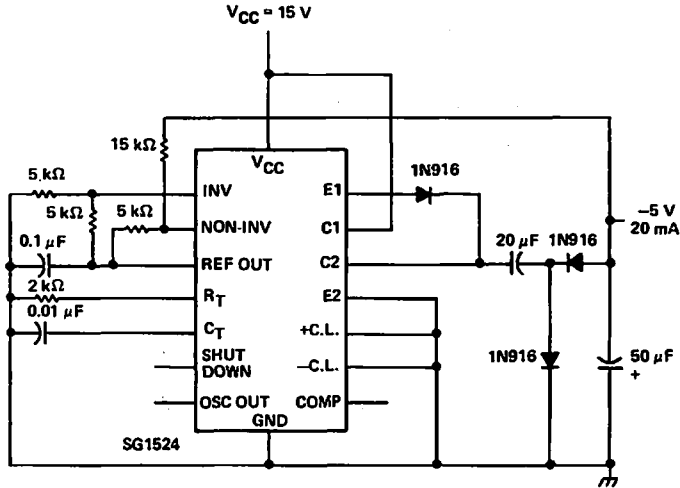


FIGURE 12—CAPACITOR-DIODE OUTPUT CIRCUIT

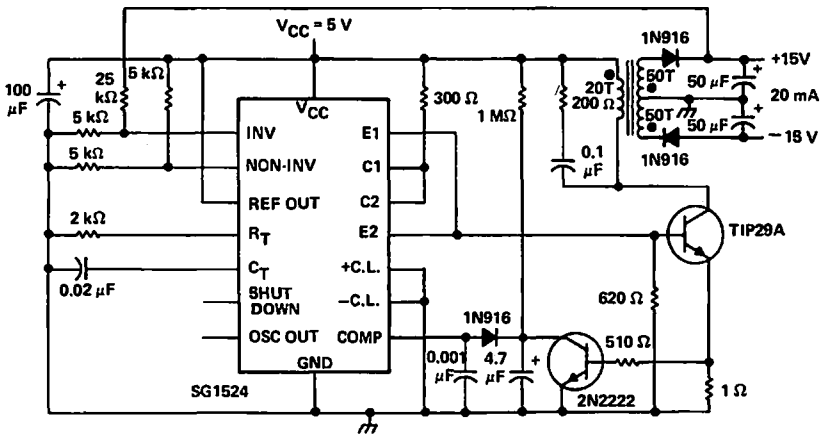


FIGURE 13 — FLYBACK CONVERTER CIRCUIT

TYPES SG1524, SG2524, SG3524 REGULATING PULSE WIDTH MODULATORS

TYPICAL APPLICATION DATA

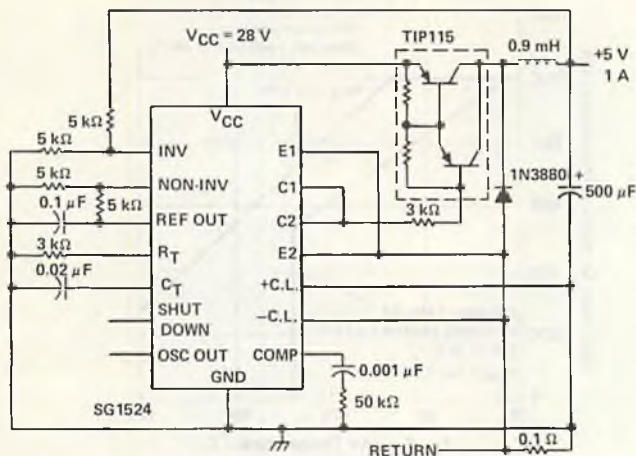


FIGURE 14—SINGLE-ENDED LC CIRCUIT

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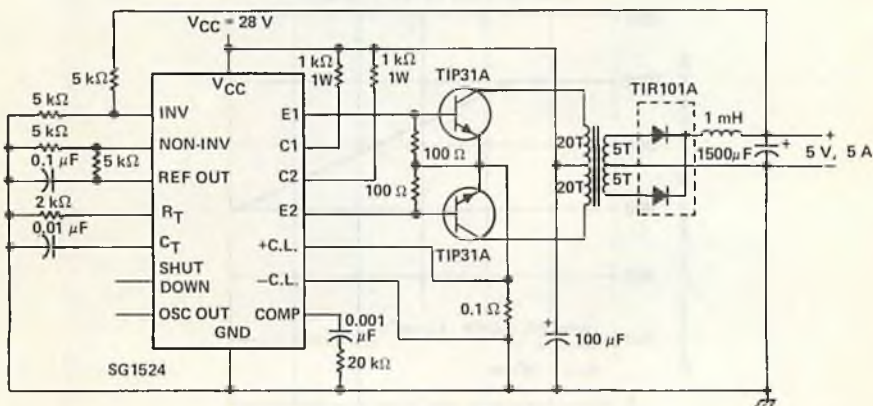


FIGURE 15—PUSH-PULL TRANSFORMER-COUPLED CIRCUIT

TYPES SG1524, SG2524, SG3524 REGULATING PULSE WIDTH MODULATORS

THERMAL INFORMATION

J PACKAGE FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

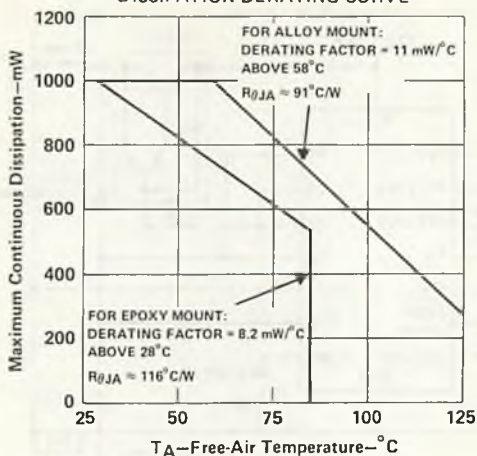


FIGURE 16

N PACKAGE FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

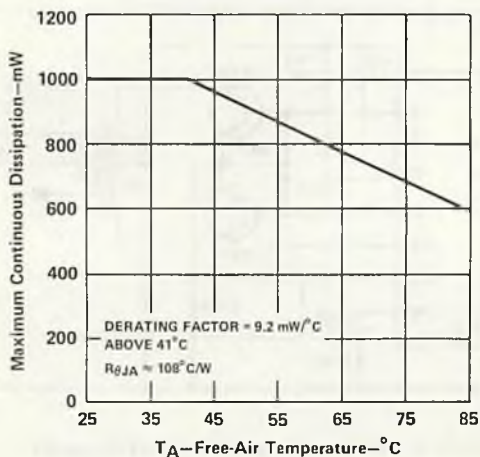
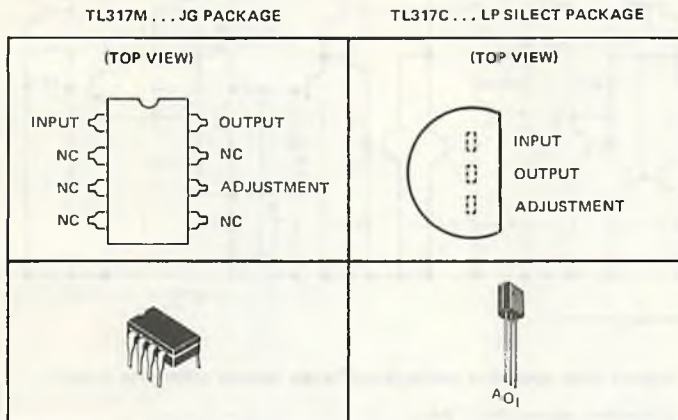


FIGURE 17

- Output Voltage Range Adjustable from 1.2 V to 32 V
- Guaranteed Output Current Capability of 100 mA
- Input Regulation Typically 0.01% Per Input-Volt Change
- Output Regulation Typically 0.5%
- Ripple Rejection Typically 80 dB

terminal assignments



2

description

The TL317 is an adjustable 3-terminal positive-voltage regulator capable of supplying 100 milliamperes over an output-voltage range of 1.2 volts to 32 volts. It is exceptionally easy to use and requires only two external resistors to set the output voltage. Both input and output regulation are better than standard fixed regulators. The device is packaged in standard packages that are easily mounted and handled.

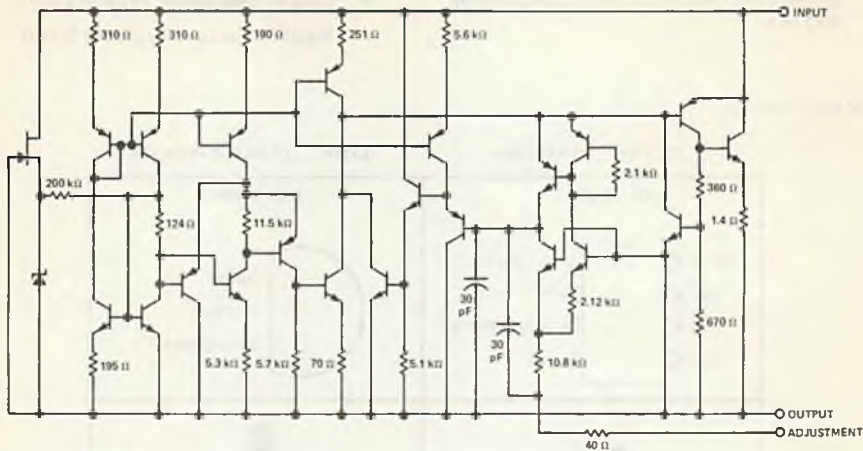
In addition to higher performance than fixed regulators, this regulator offers full overload protection available only in integrated circuits. Included on the chip are current limit and thermal overload protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected. Normally, no capacitors are needed unless the device is situated far from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection, which is difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, the regulator is useful in a wide variety of other applications. Since the regulator is floating and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input-to-output differential is not exceeded. Its primary application is that of a programmable output regulator, but by connecting a fixed resistor between the adjustment terminal and the output terminal, this device can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground, which programs the output to 1.2 volts where most loads draw little current.

The TL317M is characterized for operation over the full military temperature range from -55°C to 125°C . The TL317C is characterized for operation from 0°C to 125°C .

TYPE TL317M, TL317C
3-TERMINAL ADJUSTABLE REGULATOR

schematic



All component values shown are nominal

absolute maximum ratings over operation temperature range (unless otherwise noted)

Input-to-output differential voltage, $V_I - V_O$	35 V
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 1): JG package	1050 mW
LP package	775 mW
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	1600 mW
Operating free-air, case, or virtual junction temperature range: TL317M	-55°C to 150°C
TL317C	0°C to 150°C
Storage temperature range	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds, JG package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds, LP package	260°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Table.

DISSIPATION DERATING TABLE

PACKAGE	REFERENCE POINT	POWER RATING	DERATING FACTOR	ABOVE (T_A OR T_C)
JG	Free-air	1050 mW	8.4 mW/°C	25°C
	Case	1600 mW	38.4 mW/°C	108°C
LP	Free-air	775 mW	6.2 mW/°C	25°C
	Case	1600 mW	28.6 mW/°C	94°C

recommended operating conditions

	TL317M		TL317C		UNIT
	MIN	MAX	MIN	MAX	
Output current, I_O	2.5	100	2.5	100	mA
Operating virtual junction temperature, T_J	-55	125	0	125	°C

TYPE TL317M, TL317C 3-TERMINAL ADJUSTABLE REGULATOR

electrical characteristics over recommended ranges of operating virtual junction temperature
(unless otherwise noted)

PARAMETER	TEST CONDITIONS†	MIN	TYP	MAX	UNIT
Input regulation (see Note 2)	$V_I - V_O = 3 \text{ V to } 35 \text{ V}$, See Note 3 $T_J = 25^\circ\text{C}$ $I_O = 2.5 \text{ mA to } 100 \text{ mA}$		0.01 0.02	0.02 0.05	%/V
Ripple rejection	$V_O = 10 \text{ V}$, $V_O = 10 \text{ V}$, $f = 120 \text{ Hz}$, 10- μF capacitor between ADJ and ground		65 66	80	dB
Output regulation	$I_O = 2.5 \text{ mA to } 100 \text{ mA}$, $T_J = 25^\circ\text{C}$, See Note 3 $V_O < 5 \text{ V}$		25		mV
	$V_O > 5 \text{ V}$		0.5		%
	$I_O = 2.5 \text{ mA to } 100 \text{ mA}$, See Note 3 $V_O < 5 \text{ V}$		50		mV
	$V_O > 5 \text{ V}$		1		%
Output voltage change with temperature	$T_J = 0^\circ\text{C to } 125^\circ\text{C}$		1		%
Output voltage long-term drift (see Note 4)	After 1000 h at $T_J = 125^\circ\text{C}$ and $V_I - V_O = 35 \text{ V}$		0.3	1	%
Output noise voltage	$f = 10 \text{ Hz to } 10 \text{ kHz}$, $T_J = 25^\circ\text{C}$		0.003		%
Minimum output current to maintain regulation	$V_I - V_O = 35 \text{ V}$		1.5	2.5	mA
Peak output current	$V_I - V_O < 35 \text{ V}$	100	200		mA
Adjustment-terminal current			50	100	μA
Change in adjustment-terminal current	$V_I - V_O = 2.5 \text{ V to } 35 \text{ V}$, $I_O = 2.5 \text{ mA to } 100 \text{ mA}$		0.2	5	μA
Reference voltage (output to ADJ)	$V_I - V_O = 3 \text{ V to } 35 \text{ V}$, $I_O = 2.5 \text{ mA to } 100 \text{ mA}$, $P < \text{rated dissipation}$	1.2	1.25	1.3	V

† Unless otherwise noted, these specifications apply for the following test conditions: $V_I - V_O = 5 \text{ V}$ and $I_O = 2.5 \text{ mA}$.

NOTES: 2. Input regulation is expressed here as the percentage change in output voltage per 1-volt change at the input.

3. Input regulation and output regulation are measured using pulse techniques ($t_w < 10 \mu\text{s}$, duty cycle $< 5\%$) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.

4. Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

2

TYPICAL APPLICATION DATA

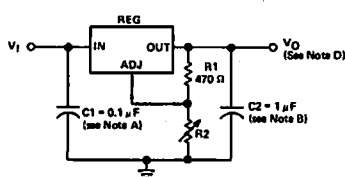


FIGURE 1—ADJUSTABLE
VOLTAGE REGULATOR

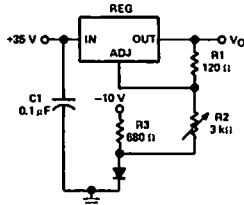
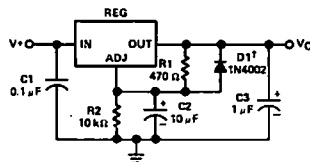


FIGURE 2—0-V to 30-V REGULATOR
CIRCUIT



† D1 discharges C2 if output
is shorted to ground.

FIGURE 3—ADJUSTABLE REGULATOR
CIRCUIT WITH IMPROVED
RIPPLE REJECTION

NOTES: A. Use of an input bypass capacitor is recommended if regulator is far from filter capacitors.

B. Use of an output capacitor improves transient response but is optional.

C. V_{ref} equals the difference between the output and adjustment terminal voltages.

D. Output voltage is calculated from the equation: $V_O = V_{ref} \left(1 + \frac{R2}{R1} \right)$

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TYPE TL317M, TL317C 3-TERMINAL ADJUSTABLE REGULATOR

TYPICAL APPLICATION DATA

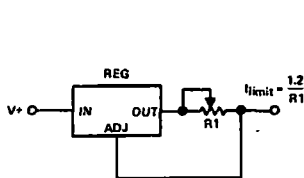


FIGURE 4—PRECISION CURRENT
LIMITER CIRCUIT

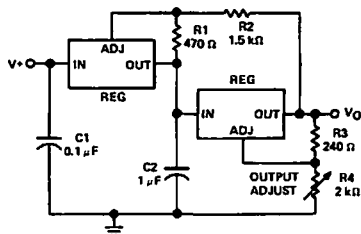


FIGURE 5—TRACKING PREREGULATOR
CIRCUIT

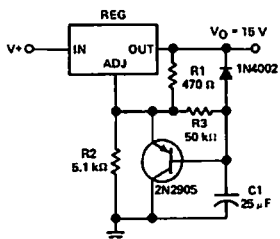


FIGURE 6—SLOW-TURN-ON 15-V
REGULATOR CIRCUIT

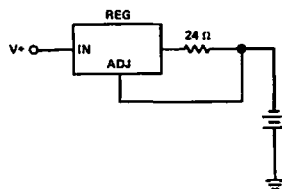
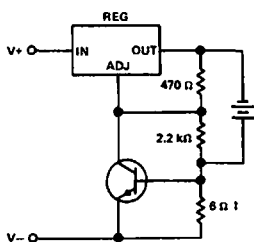
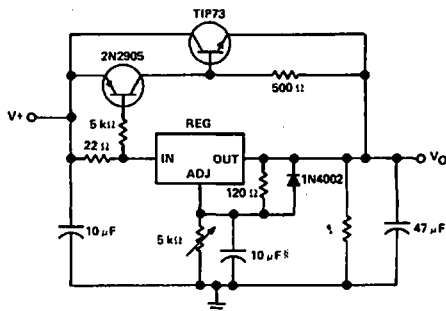


FIGURE 7—50-mA CONSTANT-CURRENT
BATTERY CHARGER CIRCUIT



‡ This resistor sets peak current (100 mA for 6 Ω).

FIGURE 8—CURRENT-LIMITED
6-V CHARGER



¶ Minimum load current is 30 mA.

§ Optional capacitor improves ripple rejection

FIGURE 9—HIGH-CURRENT ADJUSTABLE REGULATOR

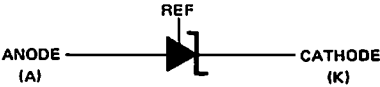
- Temperature Compensated
- Programmable Output Voltage
- Low Output Resistance
- Low Output Noise
- Sink Capability to 100 mA

description

The TL430 is a three-terminal adjustable shunt regulator featuring excellent temperature stability, wide operating current range, and low output noise. The output voltage may be set by two external resistors to any desired value between 3 volts and 30 volts. The TL430 can replace zener diodes in many applications providing improved performance.

The TL430I is characterized for operation from -25°C to 85°C , and the TL430C is characterized for operating from 0°C to 70°C .

functional block diagram



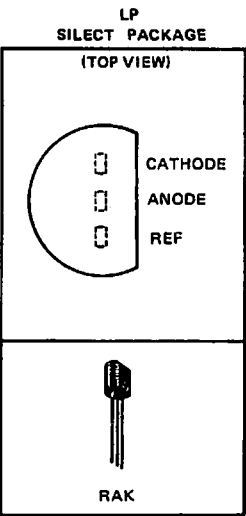
absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Regulator voltage (see Note 1)	30 V
Continuous regulator current	150 mA
Continuous dissipation at (or below) 25°C free-air temperature (see Note 2)	775 mW
Operating free-air temperature range: TL430I	-40°C to 85°C
TL430C	0°C to 70°C
Storage temperature range	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

recommended operating conditions

	MIN	MAX	UNIT
Regulator Voltage, V_Z	V_{ref}	30	V
Regulator current, I_Z	2	100	mA

- NOTES:
1. All voltage values are with respect to the anode terminal.
 2. For operation above 25°C free-air temperature, refer to Dissipation Derating Curves, Figure 5.



TYPES TL430I, TL430C ADJUSTABLE SHUNT REGULATORS

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	TEST FIGURE	TEST CONDITIONS	TL430I			TL430C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{ref} Reference input voltage	1	$V_Z = V_{ref}$, $I_Z = 10 \text{ mA}$	2.6	2.75	2.9	2.5	2.75	3	V
αV_{ref} Temperature coefficient of reference input voltage	1	$V_Z = V_{ref}$, $I_Z = 10 \text{ mA}$, $T_A = 0^\circ\text{C to } 70^\circ\text{C}$	+120	+200		+120			ppm/°C
I_{ref} Reference input current	2	$I_Z = 10 \text{ mA}$, $R_1 = 10 \text{ k}\Omega$, $R_2 = \infty$	3	10		3	10		μA
I_{ZK} Regulator current near lower knee of regulation range	1	$V_Z = V_{ref}$	0.5	2		0.5	2		mA
I_{ZM} Regulator current at maximum limit of regulation range	1	$V_Z = V_{ref}$	50			50			mA
	2	$V_Z = 5 \text{ V to } 30 \text{ V}$, See Note 3	100			100			
r_z Differential regulator resistance (see Note 4)	1	$V_Z = V_{ref}$, $\Delta I_Z = (52-2) \text{ mA}$	1.5	3		1.5	3		Ω
V_{nz} Noise voltage	2	$f = 0.1 \text{ Hz to } 10 \text{ Hz}$, $V_Z = 3 \text{ V}$	50			50			μV
		$V_Z = 12 \text{ V}$	200			200			
		$V_Z = 30 \text{ V}$	650			650			

NOTES: 3. The average power dissipation, $V_Z \cdot I_Z \cdot \text{duty cycle}$, must not exceed the maximum continuous rating in any 10-ms interval.
4. The regulator resistance for $V_Z > V_{ref}$, r_z' , is given by:

$$r_z' = r_z \left(1 + \frac{R_1}{R_2} \right)$$

PARAMETER MEASUREMENT INFORMATION

2

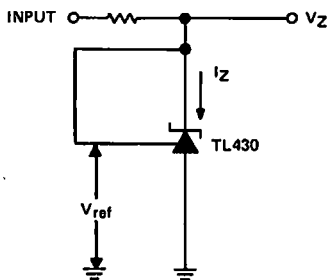
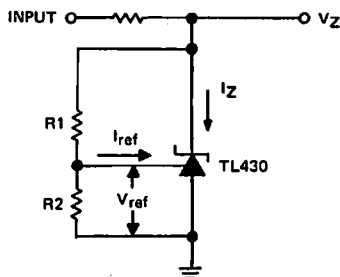


FIGURE 1—TEST CIRCUIT FOR $V_Z = V_{ref}$



$$V_Z = V_{ref} \left(1 + \frac{R_1}{R_2} \right) + I_{ref} \cdot R_1$$

FIGURE 2—TEST CIRCUIT FOR $V_Z > V_{ref}$

TYPES TL430I, TL430C ADJUSTABLE SHUNT REGULATORS

TYPICAL CHARACTERISTICS

SMALL-SIGNAL REGULATOR IMPEDANCE

vs
FREQUENCY

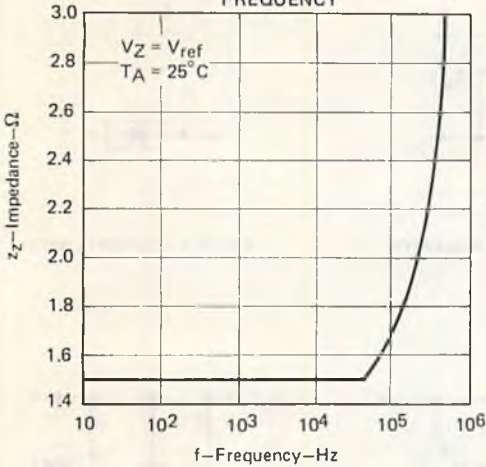


FIGURE 3

CURRENT

vs
VOLTAGE

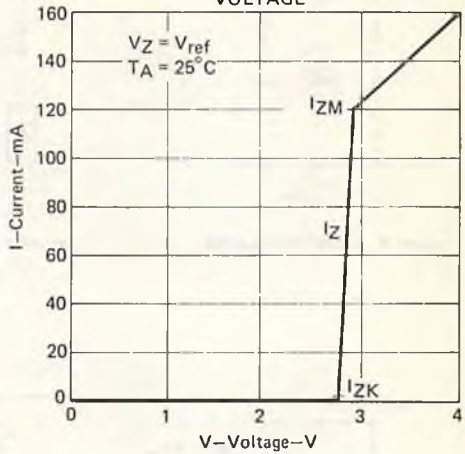


FIGURE 4

THERMAL INFORMATION

LP PACKAGE
DISSIPATION DERATING CURVE

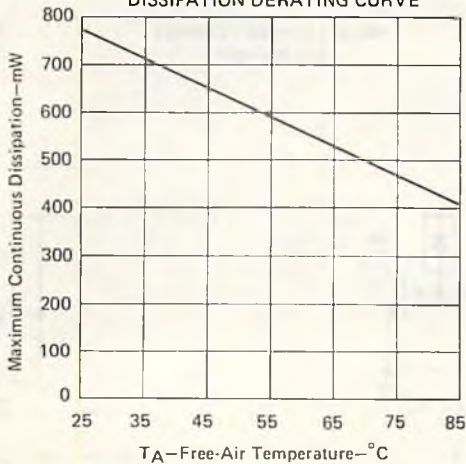


FIGURE 5

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TYPES TL430I, TL430C ADJUSTABLE SHUNT REGULATORS

TYPICAL APPLICATION DATA

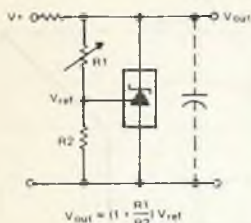


FIGURE 6—SHUNT REGULATOR

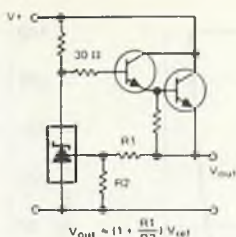


FIGURE 7—SERIES REGULATOR

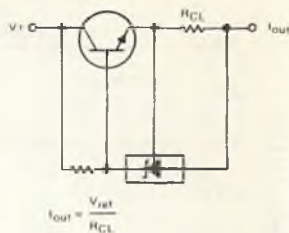


FIGURE 8—CURRENT LIMITER

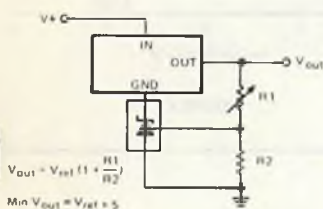


FIGURE 9—OUTPUT CONTROL OF A
THREE-THERMAL
FIXED REGULATOR

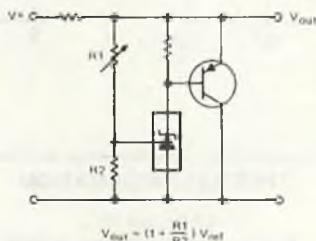


FIGURE 10—HIGHER-CURRENT
APPLICATIONS

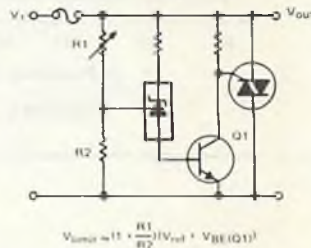


FIGURE 11—CROW BAR

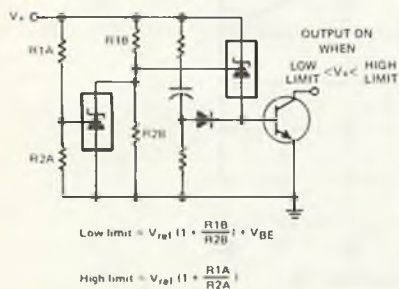


FIGURE 12—OVER-VOLTAGE/UNDER-VOLTAGE
PROTECTION CIRCUIT

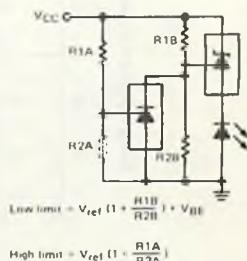


FIGURE 13— V_{CC} MONITOR

LINEAR INTEGRATED CIRCUITS

TYPES TL431M, TL431I, TL431C ADJUSTABLE PRECISION SHUNT REGULATORS

D2410, JULY 1978—REVISED DECEMBER 1982

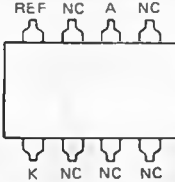
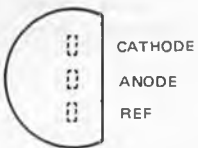
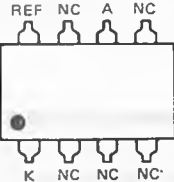



- Equivalent Full-Range Temperature Coefficient . . . 30 ppm/°C Typ
- Temperature Compensated for Operation Over Full Rated Operating Temperature Range
- Adjustable Output Voltage
- Fast Turn-On Response
- Sink Current Capability . . . 1 mA to 100 mA
- Low (0.2-Ω Typ) Dynamic Output Impedance
- Low Output Noise Voltage

description

The TL431 is a three-terminal adjustable regulator series with guaranteed thermal stability over applicable temperature ranges. The output voltage may be set to any value between V_{ref} (approximately 2.5 volts) and 36 volts with two external resistors (see Figure 16). These devices have a typical dynamic output impedance of 0.2 Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for zener diodes in many applications.

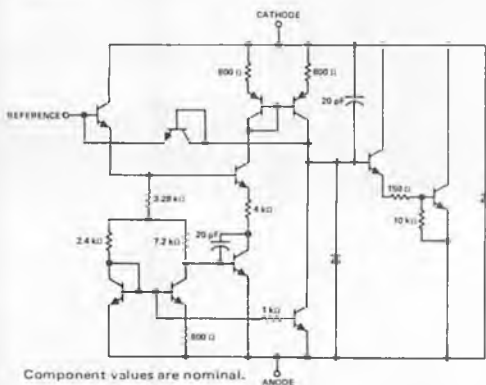
The TL431M is characterized for operation over the full military temperature range of -55°C to 125°C. The TL431I is characterized for operation from -40°C to 85°C, and the TL431C from 0°C to 70°C.

terminal assignments

TL431M . . . JG DUAL-IN-LINE PACKAGE	TL431I, TL431C . . . LP SILECT PACKAGE	TL431I, TL431C . . . P DUAL-IN-LINE PACKAGE
(TOP VIEW) 	(TOP VIEW) 	(TOP VIEW) 
	 RAK	

NC—No internal connection

schematic



functional block diagram



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TEXAS INSTRUMENTS
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TYPES TL431M, TL431I, TL431C

ADJUSTABLE PRECISION SHUNT REGULATORS

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Cathode voltage (see Note 1)	37 V
Continuous cathode current range	−100 mA to 150 mA
Reference input current range	−50 μ A to 10 mA
Continuous power dissipation at (or below) 25°C free-air temperature (see Note 2): JG package	1050 mW
LP package	775 mW
P package	1000 mW
Operating free-air temperature range: TL431C	0°C to 70°C
TL431I	−40°C to 85°C
TL431M	−55°C to 125°C
Storage temperature range	−65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: LP or P package	260°C

NOTES: 1. Voltage values are with respect to the anode terminal unless otherwise noted.

2. For operation above 25°C free-air temperature, refer to the Dissipation Derating Table.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE T_A
JG	1050 mW	8.4 mW/°C	25°C
LP	775 mW	6.2 mW/°C	25°C
P	1000 mW	8.0 mW/°C	25°C

recommended operating conditions

	MIN	MAX	UNIT
Cathode voltage, V_{KA}	V_{ref}	36	V
Cathode current, I_K , (for regulation)	1	100	mA

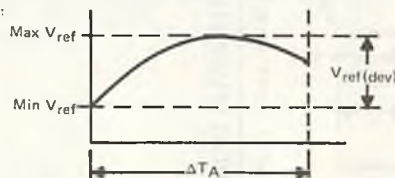
electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	TEST CIRCUIT	TEST CONDITIONS	TL431M			TL431I			TL431C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{ref} Reference input voltage	1	$V_{KA} = V_{ref}$, $I_K = 10$ mA	2440	2495	2550	2440	2495	2550	2440	2495	2550	mV
$V_{ref(dev)}$ Deviation of reference input voltage over full temperature range [†]	1	$V_{KA} = V_{ref}$, $I_K = 10$ mA, $T_A = \text{full range}^\dagger$		22	44		15	30		8	17	mV
ΔV_{ref} Ratio of change in reference input voltage to the change in cathode voltage	2	$I_K = 10$ mA, $\Delta V_{KA} = 10$ V - V_{ref} $\Delta V_{KA} = 36$ V - 10 V		-1.4	-2.7		-1.4	-2.7		-1.4	-2.7	mV
I_{ref} Reference input current	2	$I_K = 10$ mA, $R_1 = 10$ k Ω , $R_2 = \infty$		2	4		2	4		2	4	μ A
$I_{ref(dev)}$ Deviation of reference input current over full temperature range [†]	2	$I_K = 10$ mA, $R_1 = 10$ k Ω , $R_2 = \infty$ $T_A = \text{full range}^\dagger$		1	3		0.8	2.5		0.4	1.2	μ A
I_{min} Minimum cathode current for regulation	1	$V_{KA} = V_{ref}$		0.4	1		0.4	1		0.4	1	mA
I_{off} Off-state cathode current	3	$V_{KA} = 36$ V, $V_{ref} = 0$		0.1	1		0.1	1		0.1	1	μ A
$ z_{ka} $ Dynamic impedance [§]	1	$V_{KA} = V_{ref}$, $I_K = 1$ mA to 100 mA $f < 1$ kHz		0.2	0.5		0.2	0.5		0.2	0.5	Ω

[†] Full temperature range is -55°C to 125°C for the TL431M, -40°C to 85°C for the TL431I, and 0°C to 70°C for the TL431C.

[‡] The deviation parameters $V_{ref(dev)}$ and $I_{ref(dev)}$ are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The equivalent full-range temperature coefficient of the reference input voltage, αV_{ref} , is defined as:

$$\left| \alpha V_{ref} \right| \left(\frac{\text{ppm}}{^\circ\text{C}} \right) = \frac{\left(\frac{V_{ref(dev)}}{V_{ref @ 25^\circ\text{C}}} \right) \times 10^6}{\Delta T_A}$$



where ΔT_A is the rated operating free-air temperature range of the device.

αV_{ref} can be positive or negative depending on whether minimum V_{ref} or maximum V_{ref} , respectively, occurs at the lower temperature (see Figure 8).

Example: Max $V_{ref} = 2500$ mV @ 30°C, Min $V_{ref} = 2492$ mV @ 0°C, $V_{ref} = 2495$ mV @ 25°C, $\Delta T_A = 70^\circ\text{C}$ for TL431C

$$\left| \alpha V_{ref} \right| = \frac{\left(\frac{8 \text{ mV}}{2495 \text{ mV}} \right) \times 10^6}{70^\circ\text{C}} = 46 \text{ ppm}/^\circ\text{C}$$

Because minimum V_{ref} occurs at the lower temperature, the coefficient is positive.

[§] The dynamic impedance is defined as:

$$\left| z_{ka} \right| = \frac{\Delta V_{KA}}{\Delta I_K}$$

When the device is operated with two external resistors (see Figure 2), the total dynamic impedance of the circuit is given by:

$$\left| z' \right| = \frac{\Delta V}{\Delta I} \approx \left| z_{ka} \right| \left(1 + \frac{R_1}{R_2} \right)$$

TYPES TL431M, TL431I, TL431C

ADJUSTABLE PRECISION SHUNT REGULATORS

PARAMETER MEASUREMENT INFORMATION

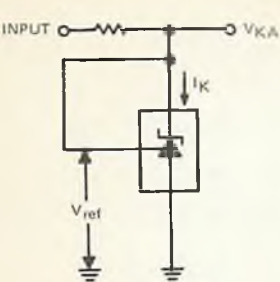


FIGURE 1—TEST CIRCUIT FOR $V_{KA} = V_{ref}$

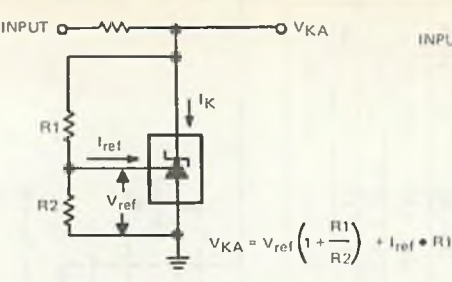


FIGURE 2—TEST CIRCUIT FOR $V_{KA} > V_{ref}$

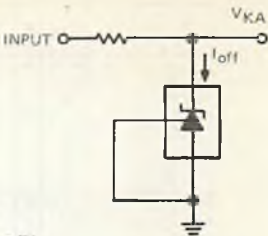


FIGURE 3—TEST CIRCUIT FOR I_{off}

TYPICAL CHARACTERISTICS

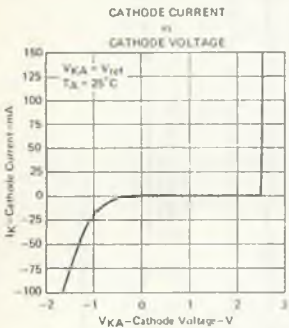


FIGURE 4

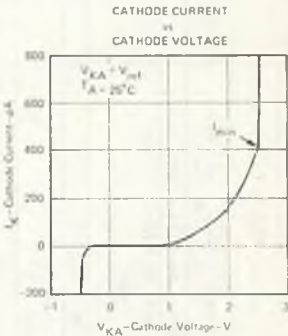


FIGURE 5

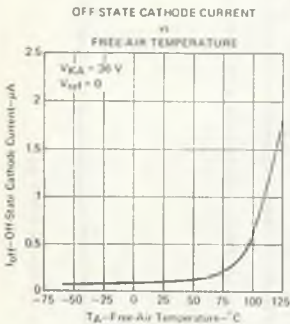


FIGURE 6

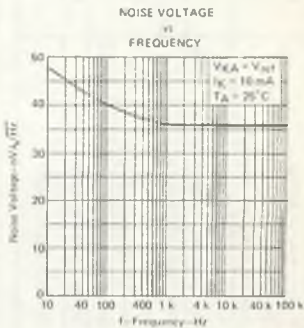


FIGURE 7

TYPES TL431M, TL431I, TL431C ADJUSTABLE PRECISION SHUNT REGULATORS

TYPICAL CHARACTERISTICS

REFERENCE INPUT VOLTAGE

vs

FREE-AIR TEMPERATURE

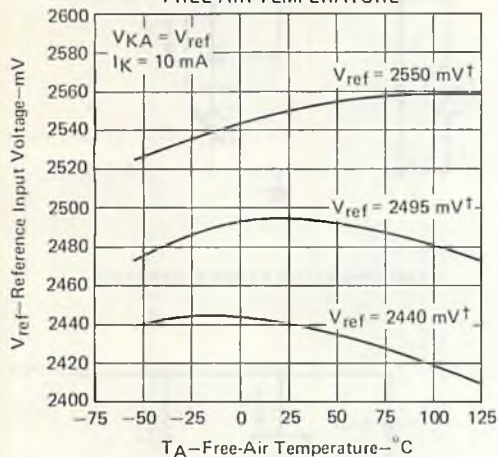


FIGURE 8

REFERENCE INPUT CURRENT

vs

FREE-AIR TEMPERATURE

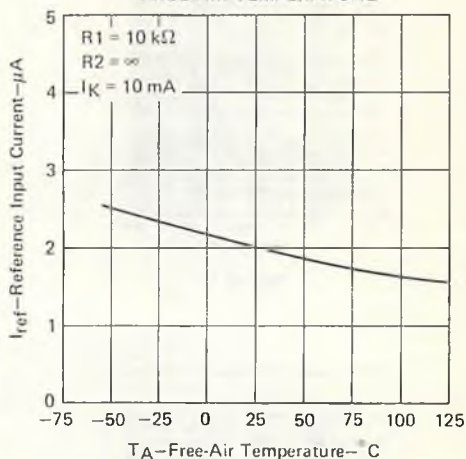


FIGURE 9

2

CHANGE IN REFERENCE INPUT VOLTAGE

vs

CATHODE VOLTAGE

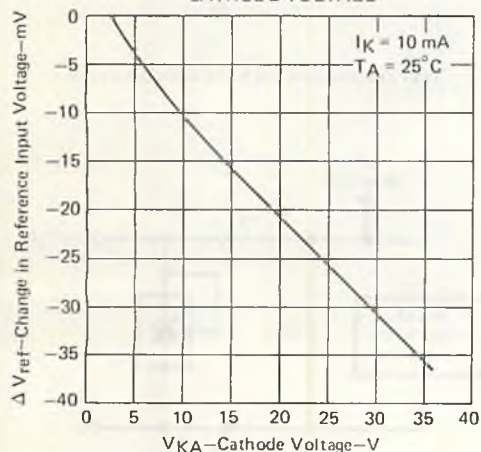


FIGURE 10

DYNAMIC IMPEDANCE

vs

FREE-AIR TEMPERATURE

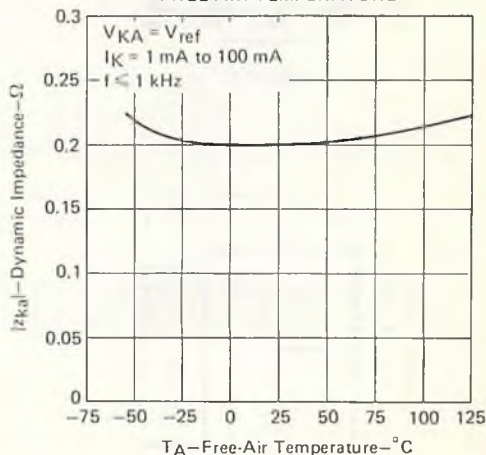


FIGURE 11

[†]Data is for devices having the indicated value of V_{ref} at $I_K = 10\text{ mA}$, $T_A = 25^\circ\text{C}$.

TYPES TL431M, TL431I, TL431C ADJUSTABLE PRECISION SHUNT REGULATORS

TYPICAL CHARACTERISTICS

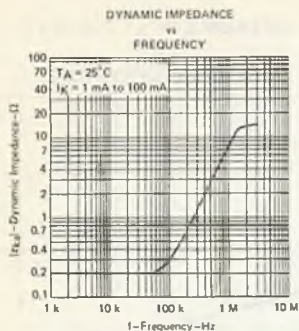
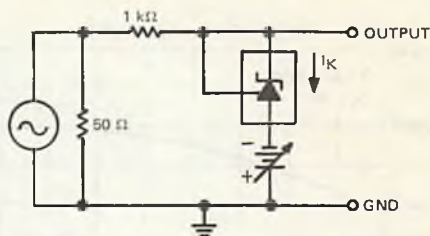


FIGURE 12



TEST CIRCUIT FOR DYNAMIC IMPEDANCE

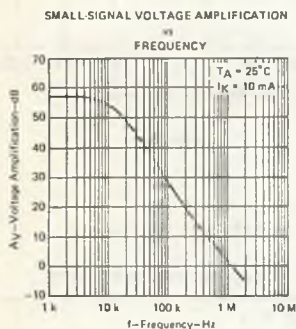
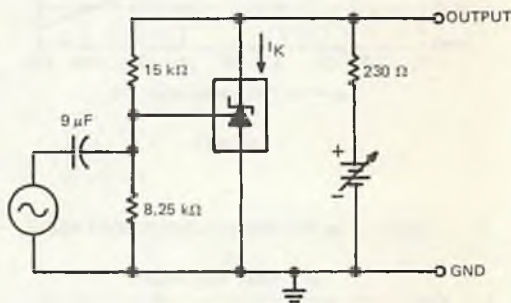


FIGURE 13



TEST CIRCUIT FOR VOLTAGE AMPLIFICATION

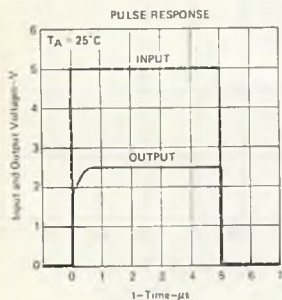
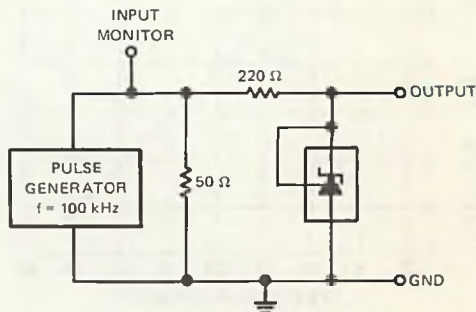


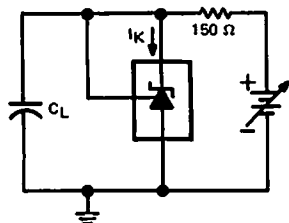
FIGURE 14



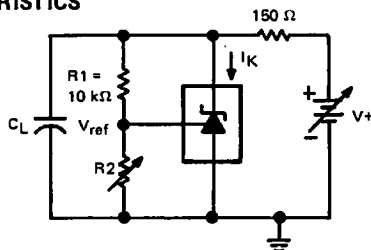
TEST CIRCUIT FOR PULSE RESPONSE

TYPES TL431M, TL431I, TL431C ADJUSTABLE PRECISION SHUNT REGULATORS

TYPICAL CHARACTERISTICS



TEST CIRCUIT FOR CURVE A BELOW



TEST CIRCUIT FOR CURVES B, C, AND D BELOW

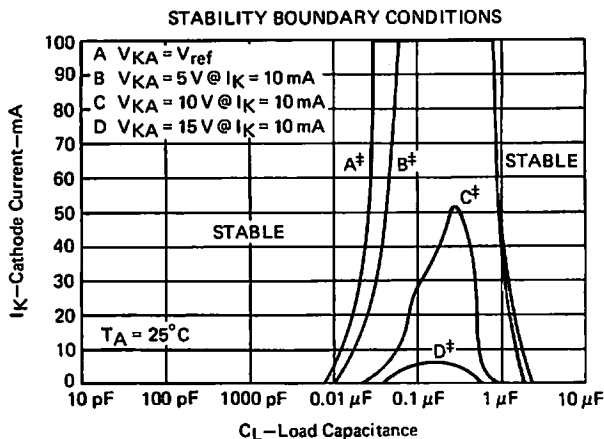


FIGURE 15

[†]The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, R2 and V+ were adjusted to establish the initial V_{KA} and I_K conditions with $C_L = 0$. V+ and C_L were then adjusted to determine the ranges of stability.

TYPICAL APPLICATIONS

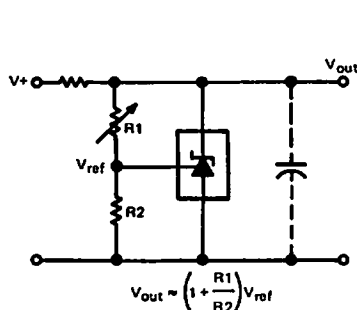


FIGURE 16-SHUNT REGULATOR

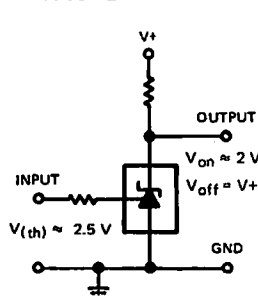


FIGURE 17-SINGLE-SUPPLY COMPARATOR
WITH TEMPERATURE-
COMPENSATED THRESHOLD

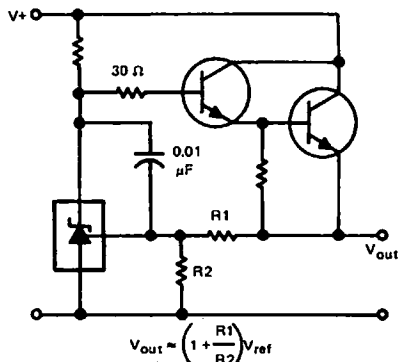


FIGURE 18-SERIES
REGULATOR

TEXAS INSTRUMENTS
INCORPORATED

POST OFFICE BOX 225012 • DALLAS, TEXAS 75285

TYPES TL431M, TL431I, TL431C

ADJUSTABLE PRECISION SHUNT REGULATORS

TYPICAL APPLICATIONS

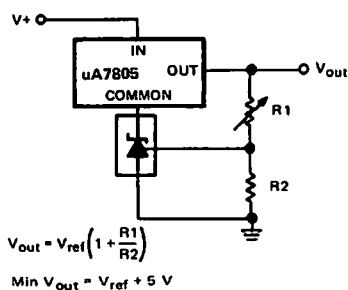


FIGURE 19—OUTPUT CONTROL OF A THREE-TERMINAL FIXED REGULATOR

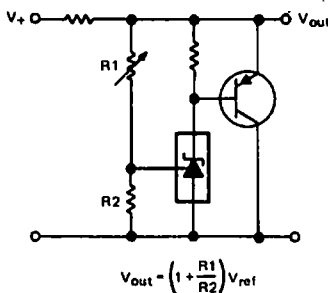


FIGURE 20—HIGHER-CURRENT SHUNT REGULATOR

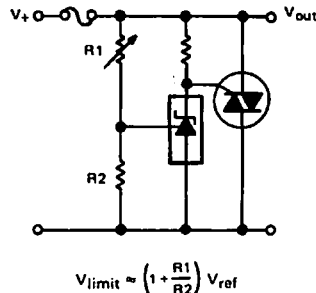


FIGURE 21—CROW BAR

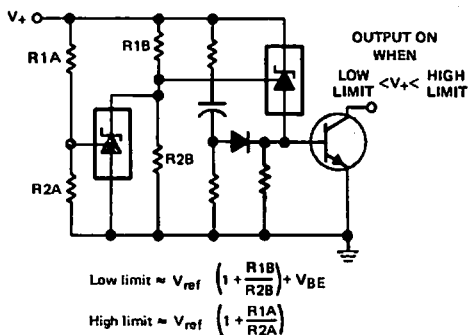


FIGURE 22—OVER-VOLTAGE/UNDER-VOLTAGE PROTECTION CIRCUIT

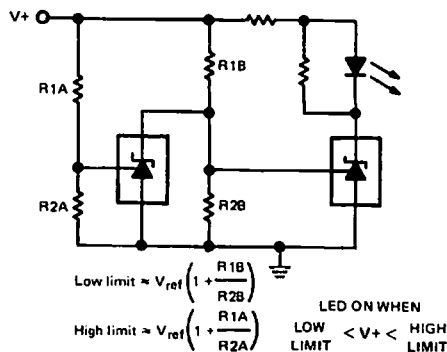


FIGURE 23—VOLTAGE MONITOR

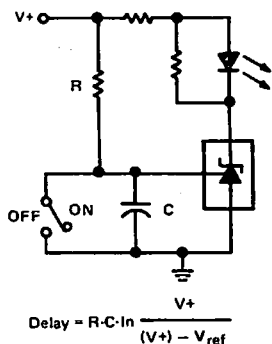


FIGURE 24—DELAY TIMER

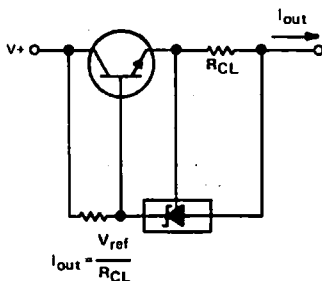


FIGURE 25—CURRENT LIMITER OR CURRENT SOURCE

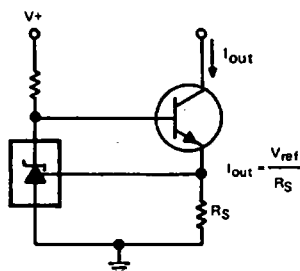


FIGURE 26—CONSTANT-CURRENT SINK

- Complete PWM Power Control Circuitry
- Uncommitted Outputs for 200-mA Sink or Source Current
- Output Control Selects Single-Ended or Push-Pull Operation
- Internal Circuitry Prohibits Double Pulse at Either Output
- Variable Dead-Time Provides Control Over Total Range
- Internal Regulator Provides a Stable 5-V Reference Supply Trimmed to 1%
- Circuit Architecture Allows Easy Synchronization
- TL493 Has Output Current-Limit Sensing
- TL495 Has On-Chip 39-V Zener and External Control of Output Steering

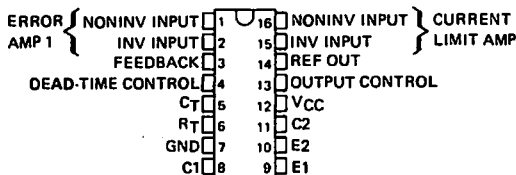
description

The TL493, TL494, and TL495 each incorporate on a single monolithic chip all the functions required in the construction of a pulse-width-modulation control circuit. Designed primarily for power supply control, these devices offer the systems engineer the flexibility to tailor the power supply control circuitry to his application.

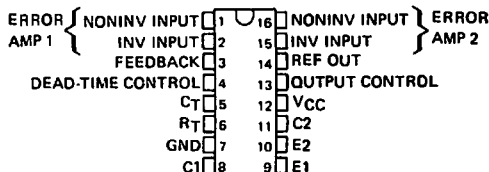
The TL493 contains an error amplifier, current-limiting amplifier, an on-chip adjustable oscillator, a dead-time control comparator, pulse-steering control flip-flop, a 5-volt, 1%-precision regulator, and output-control circuits.

The error amplifier exhibits a common-mode voltage range from -0.3 volts to $V_{CC} - 2$ volts. The current-limit amplifier exhibits a common-mode voltage range from -0.3 volts to 3 volts with an offset voltage of approximately 80 millivolts in series with the inverting input to ease circuit design requirements. The dead-time control comparator has a fixed offset that provides approximately 5% dead time when externally altered. The on-chip oscillator may be bypassed by terminating R_T (pin 6) to the reference output and providing a sawtooth input to C_T (pin 5), or it may be used to drive the common circuits in synchronous multiple-rail power supplies.

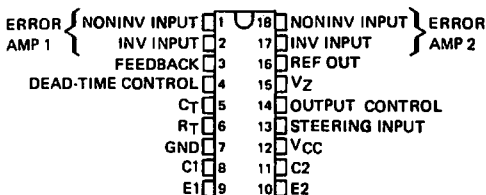
**TL493C . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)**



**TL494M . . . J
TL494I, TL494C . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)**



**TL495I, TL495C . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)**



DEVICE TYPES, SUFFIX VERSIONS, AND PACKAGES

	TL493	TL494	TL495
TL49-M	•	J	•
TL49-I	•	J,N	J,N
TL49-C	J,N	J,N	J,N

*These combinations are not defined by this data sheet.

FUNCTION TABLE

INPUTS		OUTPUT FUNCTION
OUTPUT CONTROL	STEERING INPUT (TL495 only)	
$V_I \leq 0.4$ V	Open	Single-ended or parallel output
$V_I \geq 2.4$ V	Open	Normal push-pull operation
$V_I \geq 2.4$ V	$V_I \leq 0.4$ V	PWM Output at Q1
$V_I \geq 2.4$ V	$V_I \geq 2.4$ V	PWM Output at Q2

TYPES TL493, TL494, TL495 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

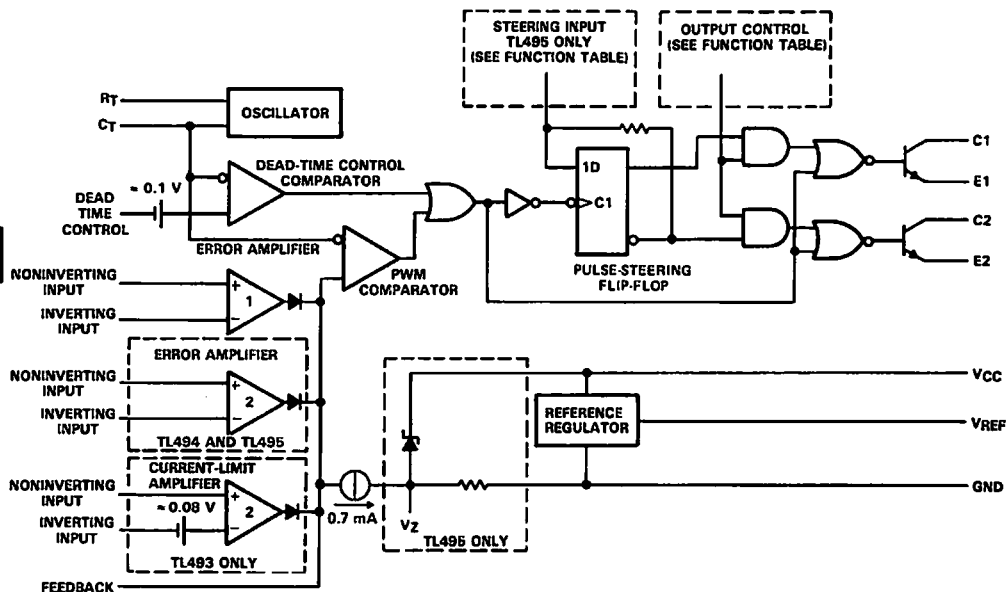
description (continued)

The uncommitted output transistors provide either common-emitter or emitter-follower output capability. Each device provides for push-pull or single-ended output operation, which may be selected through the output-control function. The architecture of these devices prohibits the possibility of either output being pulsed twice during push-pull operation.

The TL493 and TL494 are similar except that an additional error amplifier is included in the TL494 instead of a current-limiting amplifier. The TL495 provides the identical functions found in the TL494. In addition, it contains an on-chip 39-volt zener diode for high-voltage applications where V_{CC} is greater than 40 volts, and an output-steering control that overrides the internal control of the pulse-steering flip-flop.

The TL494M is characterized for operation over the full military temperature range from -55°C to 125°C . The TL494I and TL495I are characterized for operation from -25°C to 85°C . The TL493C, TL494C, and TL495C are characterized for operation from 0°C to 70°C .

functional block diagram



TYPES TL493, TL494, TL495 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

absolute maximum ratings over operating free-air temperature range
(unless otherwise noted)

	TL494M	TL494I TL495I	TL493C TL494C TL495C	UNIT
Supply voltage, V_{CC} (see Note 1)	41	41	41	V
Amplifier input voltages	$V_{CC} + 0.3$	$V_{CC} + 0.3$	$V_{CC} + 0.3$	V
Collector output voltage	41	41	41	V
Collector output current	250	250	250	mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 2)	1000	1000	1000	mW
Operating free-air temperature range	-55 to 125	-25 to 85	0 to 70	°C
Storage temperature range	-65 to 150	-65 to 150	-65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package	300	300	300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: N package		260	260	°C

- NOTES: 1. All voltage values, except differential voltages, are with respect to the network ground terminal.
2. For operation above 25°C free-air temperature, refer to Dissipation Derating Table. In the J package, TL494M chips are alloy-mounted; TL493C, TL494I, TL494C, TL495I, and TL495I chips are glass mounted.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE T_A
J (Alloy-Mounted Chip)	1000 mW	11.0 mW/°C	59°C
J (Glass-Mounted Chip)	1000 mW	8.2 mW/°C	28°C
N	1000 mW	9.2 mW	41°C

2

recommended operating conditions

	TL494M		TL494I TL495I		TL493C TL494C TL495C		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	7	40	7	40	7	40	V
Amplifier input voltages, V_I	-0.3	$V_{CC} - 2$	-0.3	$V_{CC} - 2$	-0.3	$V_{CC} - 2$	V
Collector output voltage, V_O		40		40		40	V
Collector output current (each transistor)		200		200		200	mA
Current into feedback terminal		0.3		0.3		0.3	mA
Timing capacitor, C_T	0.47	10 000	0.47	10 000	0.47	10 000	nF
Timing resistor, R_T	1.8	500	1.8	500	1.8	500	kΩ
Oscillator frequency	1	300	1	300	1	300	kHz
Operating free-air temperature, T_A	-55	125	-25	85	0	70	°C

TYPES TL493, TL494, TL495

PULSE-WIDTH-MODULATION CONTROL CIRCUITS

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 15\text{ V}$, $f = 10\text{ kHz}$ (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS†	TL494M			TL493C TL494I, TL494C TL495I, TL495C			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Output voltage (V_{ref})	$I_O = 1\text{ mA}$	4.75	5	5.25	4.75	5	5.25	V
Input regulation	$V_{CC} = 7\text{ V to }40\text{ V}$	2	25	25	2	25	25	mV
Output regulation	$I_O = 1\text{ to }10\text{ mA}$	1	15	15	1	15	15	mV
Output voltage change with temperature	$\Delta T_A = \text{MIN to MAX}$	0.2	1	1	0.2	1	1	%
Short-circuit output current§	$V_{ref} = 0$	10	35	50	35			mA

oscillator section

PARAMETER	TEST CONDITIONS†	TL494M			TL493C TL494I, TL494C TL495I, TL495C			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Frequency	$C_T = 0.01\text{ }\mu\text{F}$, $R_T = 12\text{ k}\Omega$		10			10		kHz
Standard deviation of frequency¶	All values of V_{CC} , C_T , R_T , T_A constant		10			10		%
Frequency change with voltage	$V_{CC} = 7\text{ V to }40\text{ V}$, $T_A = 25^\circ\text{C}$		0.1			0.1		%
Frequency change with temperature	$C_T = 0.01\text{ }\mu\text{F}$, $R_T = 12\text{ k}\Omega$, $\Delta T_A = \text{MIN to MAX}$			4			2	%

2

amplifier sections (see figure 1)

PARAMETER		TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Input offset voltage	Error	V _O (pin 3) = 2.5 V	2		10	mV
	current-limit (TL493 only)		80			
Input offset current		V _O (pin 3) = 2.5 V	25	250	nA	
Input bias current		V _O (pin 3) = 2.5 V	0.2	1	μA	
Common-mode input voltage range	Error	V _{CC} = 7 V to 40 V	-0.3 to V _{CC} - 2		V	
	Current-limit (TL493 only)		-0.3 to 3			
Open-loop voltage amplification	Error	ΔV _O = 3 V, V _O = 0.5 V to 3.5 V	70	95	dB	
	Current-limit (TL493 only)		90			
Unity-gain bandwidth			800		kHz	
Common-mode rejection ratio	Error	V _{CC} = 40 V, T _A = 25°C	65	80	dB	
	Current-limit (TL493 only)		70			
Output sink current (pin 3)		V _{ID} = -15 mV to -5 V, V _(pin 3) = 0.5 V	0.3	0.7	mA	
Output source current (pin 3)		V _{ID} = 15 mV to 5 V, V _(pin 3) = 3.5 V	-2		mA	

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡All typical values except for parameter changes with temperature are at $T_A = 25^\circ\text{C}$.

§Duration of the short-circuit should not exceed one second.

¶Standard deviation is a measure of the statistical distribution about the mean as derived from the formulae $\sigma = \sqrt{\frac{\sum_{n=1}^N (x_n - \bar{x})^2}{N-1}}$

TYPES TL493, TL494, TL495 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 15\text{ V}$, $f = 10\text{ kHz}$ (unless otherwise noted)

output section

PARAMETER	TEST CONDITIONS	TL494M			TL493C TL494I, TL494C TL495I, TL495C			UNIT
		MIN	TYP [‡]	MAX	MIN	TYP [‡]	MAX	
Collector off-state current	$V_{CE} = 40\text{ V}$, $V_{CC} = 40\text{ V}$		2	100		2	100	μA
Emitter off-state current	$V_{CC} = V_C = 40\text{ V}$, $V_E = 0$			-150			-100	μA
Collector-emitter saturation voltage	Common-emitter $V_E = 0$, $I_C = 200\text{ mA}$		1.1	1.5		1.1	1.3	V
	Emitter-follower $V_C = 15\text{ V}$, $I_E = -200\text{ mA}$		1.5	2.5		1.5	2.5	
Output control input current	$V_I = V_{ref}$			3.5			3.5	mA

dead-time control-section (see figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Input bias current (pin 4)	$V_I = 0\text{ to }5.25\text{ V}$		-2	-10	μA
Maximum duty cycle, each output	V_I (pin 4) = 0	45			%
Input threshold voltage (pin 4)	Zero duty cycle		3	3.3	V
	Maximum duty cycle	0			

pwm comparator section (see figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Input threshold voltage (pin 3)	Zero duty cycle		4	4.5	V
Input sink current (pin 3)	$V_{(pin\ 3)} = 0.7\text{ V}$	0.3	0.7		mA

steering control (TL495 only)

PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
Input current	$V_I = 0.4\text{ V}$		-200	μA
	$V_I = 2.4\text{ V}$		200	

zener-diode circuit (TL495 only)

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Breakdown voltage	$V_{CC} = 41\text{ V}$, $I_Z = 2\text{ mA}$		39		V
Sink current	$V_{I(pin\ 15)} = 1\text{ V}$	0.3			mA

total device

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Standby supply current	Pin 6 at V_{ref} , All other inputs and outputs open	$V_{CC} = 15\text{ V}$	6	10	mA
		$V_{CC} = 40\text{ V}$	9	15	
Average supply current	$V_{(pin\ 4)} = 2\text{ V}$, See Figures 1		7.5		mA

switching characteristics, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Output voltage rise time	Common-emitter configuration, See Figure 3		100	200	ns
Output voltage fall time			25	100	
Output voltage rise time	Emitter-follower configuration, See Figure 4		100	200	ns
Output voltage fall time			40	100	ns

[‡]All typical values except for temperature coefficients are at $T_A = 25^\circ\text{C}$.

PARAMETER MEASUREMENT INFORMATION

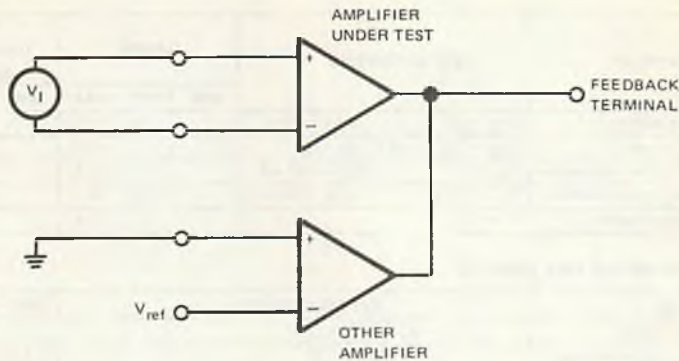


FIGURE 1 — AMPLIFIER CHARACTERISTICS

2

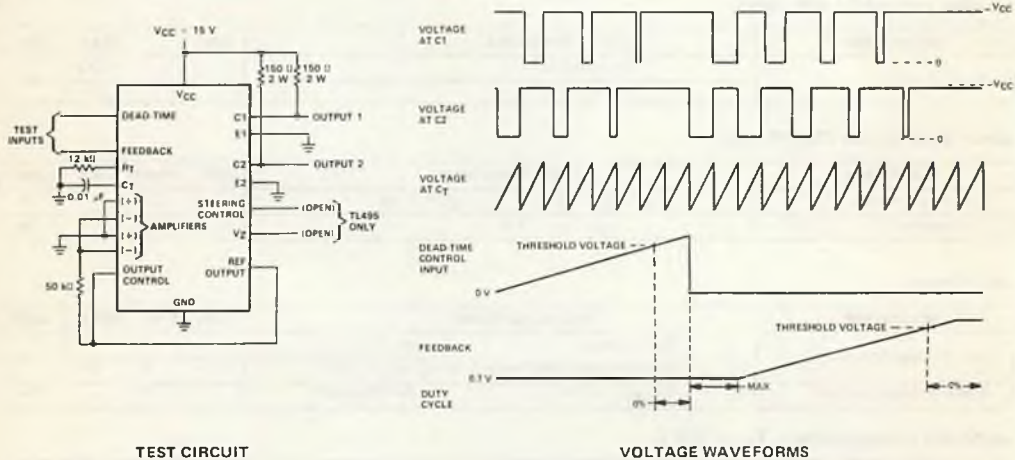
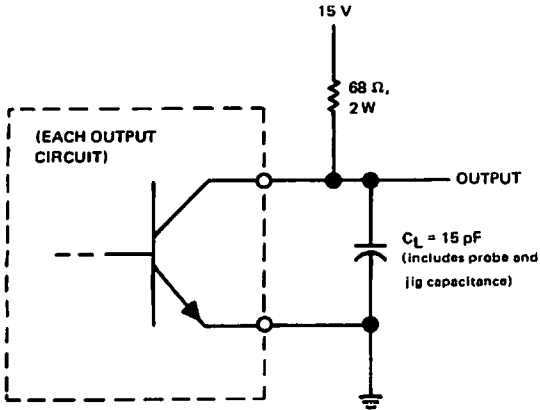
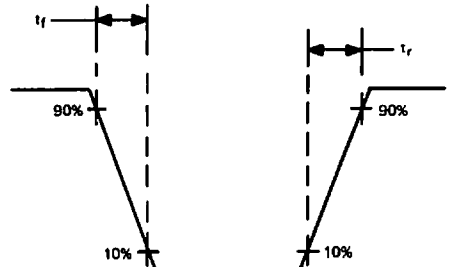


FIGURE 2 — DEAD-TIME AND FEEDBACK CONTROL

PARAMETER MEASUREMENT INFORMATION



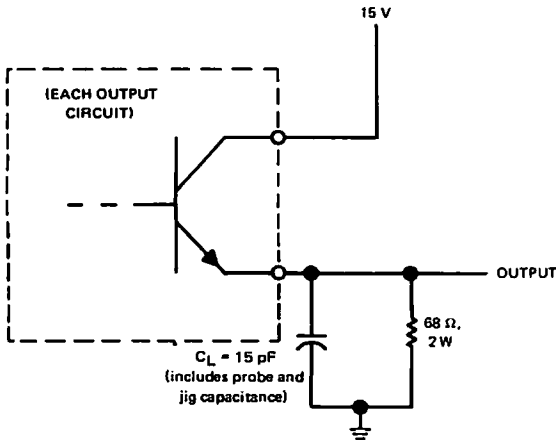
TEST CIRCUIT



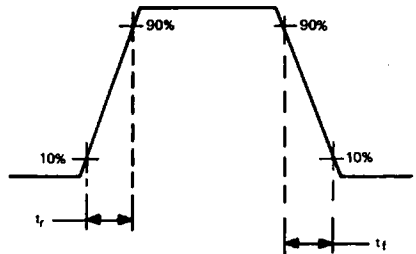
OUTPUT VOLTAGE WAVEFORM

FIGURE 3—COMMON-EMITTER CONFIGURATION

2



TEST CIRCUIT



OUTPUT VOLTAGE WAVEFORM

FIGURE 4—EMITTER-FOLLOWER CONFIGURATION

TYPES TL493, TL494, TL495 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

TYPICAL CHARACTERISTICS

OSCILLATOR FREQUENCY and
FREQUENCY VARIATION[†] vs
TIMING RESISTANCE

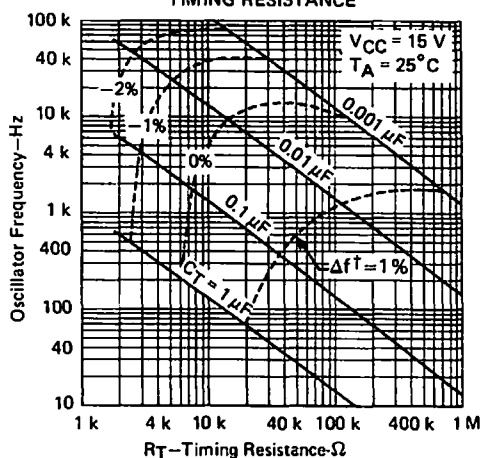


FIGURE 5

AMPLIFIER VOLTAGE AMPLIFICATION
vs
FREQUENCY

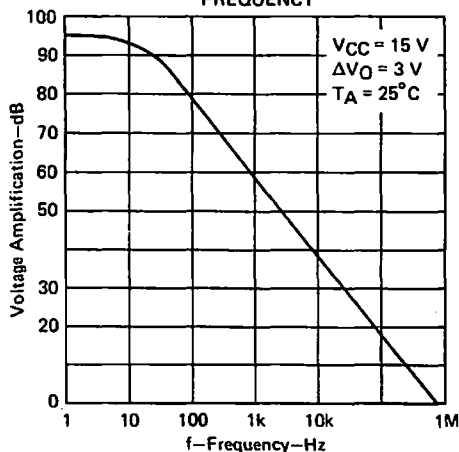
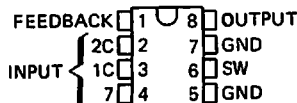


FIGURE 6

[†]Frequency variation (Δf) is the change in oscillator frequency that occurs over the full temperature range.

- Internal Step-Up Switching Regulator
- Fixed 9-Volt Output
- Charges Battery Source During Transformer-Coupled-Input Operation
- Minimum External Components Required (1 Inductor, 1 Capacitor, 1 Diode)
- 1- or 2-Cell-Input Operation

JG OR P
DUAL-IN-LINE PACKAGE
(TOP VIEW)



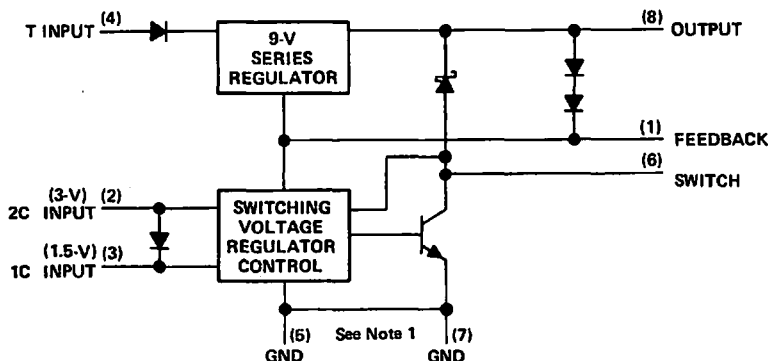
Pins 5 and 7 are connected together internally.

description

The TL496 power supply control circuit is designed to provide a 9-volt regulated supply from a variety of input sources. Operable from a 1- or 2-cell-battery input, the TL496 performs as a switching regulator with the addition of a single inductor and filter capacitor. When ac coupled with a step-down transformer, the TL496 operates as a series regulator to maintain the regulated output voltage and, with the addition of a single catch diode, time shares to recharge the input batteries.

The design of the TL496 allows minimal supply current drain during stand-by operation (125 μ A typical). With most battery sources this allows a constant bias to be maintained on the power supply. This makes power instantly available to the system thus eliminating power-up sequencing problems.

functional block diagram



NOTE 1: Pins 5 and 7, though connected together internally, must both be terminated to ground to ensure proper circuit operation.

TYPE TL496C

9-VOLT POWER-SUPPLY CONTROLLER

absolute maximum ratings

Input voltage:

Pin 2	3.5 V
Pin 3	2.5 V
Pin 4	20 V

Output voltage (Pin 6) 12 V

Diode reverse voltage (Pin 8) 12 V

Switch current (Pin 6) 1.2 A

Diode current (Pin 8) 1.2 A

Operating free-air temperature 0°C to 70°C

Storage temperature range -65°C to 150°C

Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds 260°C

electrical characteristics at 25°C free-air temperature

series regulator section (input is pin 4)

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Dropout voltage	$V_I = 5 \text{ V}$	$I_O = -50 \text{ mA}$	1.5	2		V
Regulated output voltage	$V_I = 20 \text{ V}$	$I_O = -50 \mu\text{A}$	9.5	10.1	11.2	V
		$I_O = -80 \text{ mA}$	9.0	10.0	11.0	
	$V_I = 20 \text{ V}$, Pin 1 shorted to pin 8	$I_O = -50 \mu\text{A}$	8.5	9.0	9.7	
		$I_O = -80 \text{ mA}$	6.7	8.6	9.5	
Standby current (pin 4)	$V_I = 20 \text{ V}$	Pin 8 at 12 V		400		μA
Reverse current thru pin 4	$V_I = -1.5 \text{ V}$	1 mA into Pin 8		-25		μA

output switch

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{CE(sat)}$ Collector-emitter saturation voltage	800 mA into Pin 6,	Pin 2 at 2.25 V	0.35	0.6		V

diode (pin 6 to pin 8)

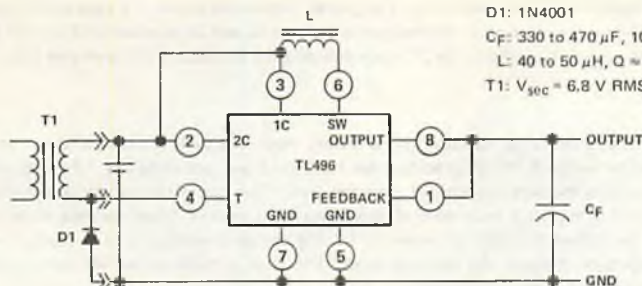
PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_F Forward voltage	$I_F = 1.5 \text{ A}$		1.6	2.5		V
I_R Reverse current thru pin 6	Pin 6 at 0 V,	1 mA into Pin 8		-20		μA

control section

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
On-state current (pin 2)	Pins 1 and 8 at 0 V,	Pin 2 at 3 V		60	100	mA
Standby current (pin 1)	Pin 1 at 8.65 V,	Pins 2 and 6 at 3 V		40		μA
Standby current (pin 2 and 6)	Pin 1 at 8.65 V,	Pins 2 and 6 at 3 V		400		μA
Start-up current (current into pin 6 to initiate cycle)	Pins 1, 2, 6 and 8 at 2.25 V		16			mA

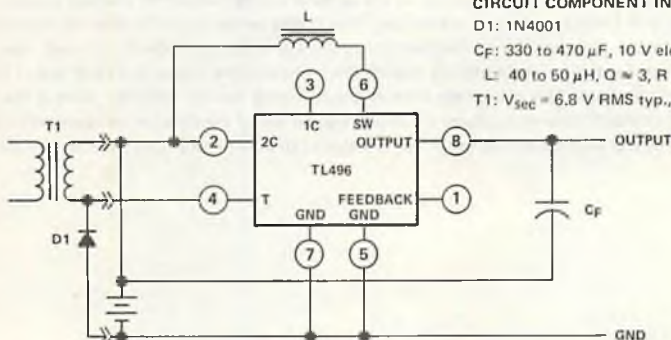
TYPE TL496C 9-VOLT POWER-SUPPLY CONTROLLER

TYPICAL APPLICATION DATA



CIRCUIT COMPONENT INFORMATION
D1: 1N4001
 C_F : 330 to 470 μ F, 10 V, electrolytic
L: 40 to 50 μ H, $Q \approx 3$, $R < 0.15 \Omega$
T1: $V_{sec} = 6.8$ V RMS typ., $R_{sec} = 11 \Omega$ typ.

FIGURE 1—ONE-CELL OPERATION



CIRCUIT COMPONENT INFORMATION
D1: 1N4001
 C_F : 330 to 470 μ F, 10 V electrolytic
L: 40 to 50 μ H, $Q \approx 3$, $R < 0.15 \Omega$
T1: $V_{sec} = 6.8$ V RMS typ., $R_{sec} = 11 \Omega$ typ.

FIGURE 2—TWO-CELL OPERATION

recommended operating conditions

	MIN	MAX	UNIT
Input voltage, one-cell operation (pins 2 and 3 to ground)	1.1	1.5	V
Input voltage, two-cell operation (pin 2 to ground)	2.3	3	V
Input voltage, one-cell or two-cell operation (pin 4 to ground)	$V_O + 2$	20	V

typical electrical characteristics for circuits above

PARAMETER		ONE-CELL OPERATION (FIGURE 1)	TWO-CELL OPERATION (FIGURE 2)
Input current	No load	125 μ A	125 μ A
	$R_L = 120 \Omega$	525 mA	405 mA
	Without T1	7.2 V	8.6 V
Output voltage	With T1	8.6 V	10 V
Output current capability		40 mA	80 mA
Efficiency		66%	66%
Battery life (AA NiCad) no load		60 days	166 days

TYPE TL496C

9-VOLT POWER-SUPPLY CONTROLLER

functional description

The TL496 is designed to operate from either a single-cell or two-cell source. To operate the device from a single cell (1.1 V to 1.5 V) the source must be connected to both inputs 1C and 2C as shown in Figure 1. For two-cell operation (2.3 V to 3.0 V), the input is applied to the 2C input only and the 1C input is left open (see Figure 2).

battery operation

The TL496 operates as a switching regulator from a battery input. The cycle is initiated when a low voltage condition is sensed by the internal feedback (the thresholds at pin 1 and pin 8 are approximately 7.2 and 8.6 volts respectively). An internal latch is set and the output transistor is turned "on." This causes the current in the external inductor (L) to increase linearly until it reaches a peak value of approximately 1 ampere. When the peak current is sensed the internal latch is reset and the output transistor is turned "off." The energy developed in the inductor is then delivered to the output storage capacitor through the blocking diode. The latch remains in the off state until the feedback signal indicates the output voltage is again deficient.

transformer-coupled operation

The TL496 operates on alternate half cycles of the ac input during transformer-coupled operation to, first, sustain the output voltage and, second, recharge the batteries. The TL496 performs like a series regulator to supply charge to the output filter/storage capacitor during the first half cycle. The output voltage of the series regulator is slightly higher voltage than that created by the switching circuit; this maintains the feedback voltage above the switching regulator control circuit threshold. This effectively inhibits the switching control circuitry. During the second half cycle an external diode (1N4001) is used to clamp the negative going end of the transformer secondary to ground thus allowing the positive-going end (end connected to V+ side of battery) to pump charge into the stand-by batteries.

LINEAR INTEGRATED CIRCUITS

TYPES TL497AM, TL497AI, TL497AC SWITCHING VOLTAGE REGULATORS

D2225, JUNE 1976—REVISED JANUARY 1983

- All Monolithic
- High Efficiency . . . 60% or Greater
- Output Current . . . 500 mA
- Input Current Limit Protection
- TTL Compatible Inhibit
- Adjustable Output Voltage
- Input Regulation . . . 0.2% Typ
- Output Regulation . . . 0.4% Typ
- Soft Start-up Capability

description

The TL497A incorporates on a single monolithic chip all the active functions required in the construction of a switching voltage regulator. It can also be used as the control element to drive external components for high-power-output applications. The TL497A was designed for ease of use in step-up, step-down, or voltage inversion applications requiring high efficiency.

A block diagram of the TL497A is shown in the above pinout. The TL497A is a fixed-on-time variable-frequency switching voltage regulator control circuit. The on time is programmed by a single external capacitor connected between the frequency control pin and ground. This capacitor, C_T , is charged by an internal constant-current generator to a predetermined threshold. The charging current and the threshold vary proportionally with V_{CC} , thus the on time remains constant over the specified range of input voltage (5 to 12 volts). Typical on times for various values of C_T are as follows:

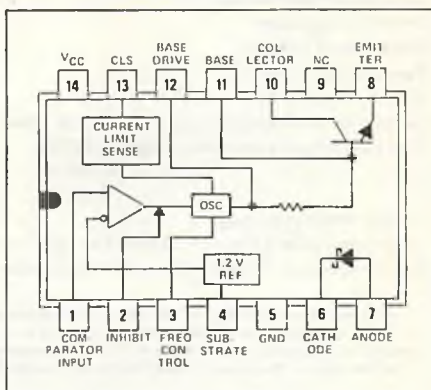
TIMING CAPACITOR, C_T (pF)	200	250	350	400	500	750	1000	1500	2000
ON-TIME (μ s)	19	22	26	32	44	56	80	120	180

The output voltage is controlled by an external resistor ladder network (R_1 and R_2 in Figures 1, 2, and 3) that provides a feedback voltage to the comparator input. This feedback voltage is compared to the reference voltage of 1.2 volts (relative to the substrate pin) by the high-gain comparator. When the output voltage decays below the value required to maintain 1.2 V at the comparator input, the comparator enables the oscillator circuit, which charges and discharges C_T as described above. The internal pass transistor is driven on during the charging of C_T . The internal transistor may be used directly for switching currents up to 500 milliamperes. Its collector and emitter are uncommitted and it is current driven to allow operation from the positive supply voltage or ground. An internal Schottky diode matched to the current characteristics of the internal transistor is also available for blocking or commutating purposes. The TL497A also has on-chip current-limit circuitry that senses the peak currents in the switching regulator and protects the inductor against saturation and the pass transistor against overstress. The current limit is adjustable and is programmed by a single sense resistor, R_{CL} , connected between pin 14 and pin 13. The current-limit circuitry is activated when 0.7 volt is developed across R_{CL} . External gating is provided by the inhibit input. When the inhibit input is high, the output is turned off.

Simplicity of design is a primary feature of the TL497A. With only six external components (three resistors, two capacitors, and one inductor), the TL497A will operate in numerous voltage conversion applications (step-up, step-down, invert) with as much as 85% of the source power delivered to the load. The TL497A replaces the TL497 in all applications.

The TL497AM is characterized for operation over the full military temperature range of -55°C to 125°C , the TL497AI is characterized for operation from -25°C to 85°C , and the TL497AC from 0°C to 70°C .

TL497AM . . . J
TL497AI, TL497AC . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)



NC—No internal connection

2

TYPES TL497AM, TL497AI, TL497AC

SWITCHING VOLTAGE REGULATORS

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Input voltage, V_{CC} (see Note 1)	15 V
Output voltage	35 V
Comparator input voltage	5 V
Inhibit input voltage	5 V
Diode reverse voltage	35 V
Power switch current	750 mA
Diode forward current	750 mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 2)	1000 mW
Operating free-air temperature range: TL497AM	-55°C to 125°C
TL497AI	-25°C to 85°C
TL497AC	0°C to 70°C
Storage temperature range	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: N package	260°C

NOTES: 1. All voltage values except diode voltages are with respect to network ground terminal.

2. Above 28°C free-air temperature, derate the N package at the rate of 9.2 mW/°C. Above 41°C free-air temperature, derate the J glass-mounted package at the rate of 8.2 mW/°C. Above 59°C free-air temperature, derate the J alloy-mounted package at the rate of 11.0 mW/°C. In the J package, TL497AM chips are alloy-mounted; TL497AC chips are glass-mounted.

recommended operating conditions

	MIN	MAX	UNIT
Input voltage, V_I	4.5	12	V
Output voltage: step-up configuration (see Figure 1)	$V_I + 2$	30	V
step-down configuration (see Figure 2)	V_{ref}	$V_I - 1$	V
inverting regulator (see Figure 3)	$-V_{ref}$	-25	V
Power switch current		500	mA
Diode forward current		500	mA

electrical characteristics at specified free-air temperature, $V_I = 6$ V (unless otherwise noted)

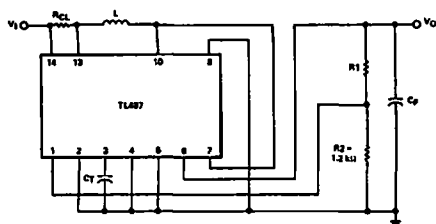
PARAMETER	TEST CONDITIONS†		TL497AM, TL497AI			TL497AC			UNIT	
			MIN	TYP‡	MAX	MIN	TYP‡	MAX		
High-level inhibit input voltage			25 °C				2.5		V	
Low-level inhibit input voltage			25 °C					0.8	V	
High-level inhibit input current	$V_{I(II)} = 5\text{ V}$		Full range		0.8	1.5		0.8	1.5	
Low-level inhibit input current	$V_{I(II)} = 0\text{ V}$		Full range		5	20		5	10	
Comparator reference voltage	$V_I = 4.5\text{ V to }6\text{ V}$		Full range		1.14	1.20	1.26	1.08	1.20	1.32
Comparator input bias current	$V_I = 6\text{ V}$		Full range			40	100		40	100
Switch on-state voltage	$V_I = 4.5\text{ V}$	$I_Q = 100\text{ mA}$	25 °C			0.13	0.2		0.13	0.2
		$I_Q = 500\text{ mA}$	Full range				1			0.85
Switch off-state current	$V_I = 4.5\text{ V}, V_O = 30\text{ V}$	25 °C			10	50		10	50	
		Full range				500			200	
Current-limit sense voltage	$V_I = 6\text{ V}$		25 °C		0.45		1	0.45		1
Diode forward voltage	$I_Q = 10\text{ mA}$		Full range			0.75	0.95		0.75	0.85
	$I_Q = 100\text{ mA}$		Full range			0.9	1.1		0.9	1
	$I_Q = 500\text{ mA}$		Full range			1.33	1.75		1.33	1.55
	$I_Q = 500\text{ }\mu\text{A}$		Full range		30					
Diode reverse voltage	$I_Q = 200\text{ }\mu\text{A}$		Full range					30		V
On-state supply current			25 °C			11	14		11	14
			Full range				16			15
Off-state supply current			25 °C			6	9		6	9
			Full range				11			10

† Full range for TL497AM is -55°C to 125°C, for TL497AI is -25°C to 85°C, and for TL497AC is 0°C to 70°C.

‡ All typical values are at $T_A = 25^\circ\text{C}$.

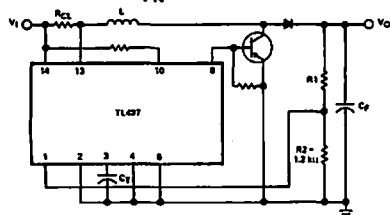
TYPES TL497AM, TL497AI, TL497AC, SWITCHING VOLTAGE REGULATORS

TYPICAL APPLICATION DATA



BASIC CONFIGURATION

($I_{PK} < 500 \text{ mA}$)



EXTENDED POWER CONFIGURATION

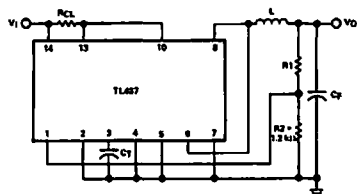
(USING EXTERNAL TRANSISTOR)

DESIGN EQUATIONS

- $I_{PK} = 2 I_O \max \left[\frac{V_O}{V_I} \right]$
- $L (\mu\text{H}) = \frac{V_I}{I_{PK}} t_{on} (\mu\text{s})$
- Choose L (50 to 500 μH), calculate t_{on} (25 to 150 μs)
- $C_T (\text{pF}) \approx 12 t_{on} (\mu\text{s})$
- $R_1 = (V_O - 1.2) \text{ k}\Omega$
- $R_{CL} = \frac{0.5 \text{ V}}{I_{PK}}$
- $C_F (\mu\text{F}) \approx t_{on} \left[\frac{\frac{V_I}{V_O} I_{PK} + I_O}{V_{\text{ripple}} (\text{PK})} \right]$

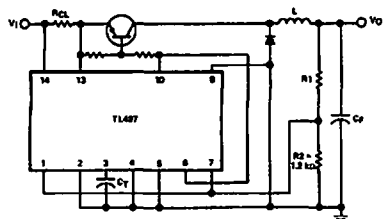
FIGURE 1—POSITIVE REGULATOR, STEP-UP CONFIGURATIONS

2



BASIC CONFIGURATION

($I_{PK} < 500 \text{ mA}$)



EXTENDED POWER CONFIGURATION

(USING EXTERNAL TRANSISTOR)

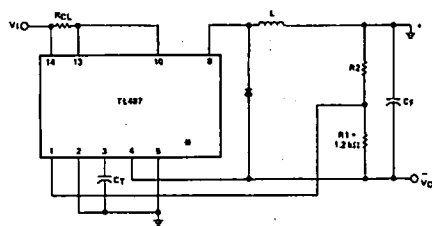
DESIGN EQUATIONS

- $I_{PK} = 2 I_O \max$
- $L (\mu\text{H}) = \frac{V_I - V_O}{I_{PK}} t_{on} (\mu\text{s})$
- Choose L (50 to 500 μH), calculate t_{on} (10 to 150 μs)
- $C_T (\text{pF}) \approx 12 t_{on} (\mu\text{s})$
- $R_1 = (V_O - 1.2) \text{ k}\Omega$
- $R_{CL} = \frac{0.5 \text{ V}}{I_{PK}}$
- $C_F (\mu\text{F}) \approx t_{on} \left[\frac{\frac{V_I}{V_O} I_{PK} + I_O}{V_{\text{ripple}} (\text{PK})} \right]$

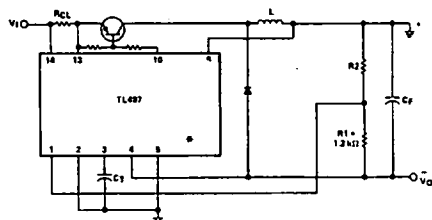
FIGURE 2—POSITIVE REGULATOR, STEP-DOWN CONFIGURATIONS

TYPES TL497AM, TL497AI, TL497AC SWITCHING VOLTAGE REGULATORS

TYPICAL APPLICATION DATA



BASIC CONFIGURATION
($I_{PK} < 500 \text{ mA}$)



EXTENDED POWER CONFIGURATION
(USING EXTERNAL TRANSISTOR)

$$I_{PK} = 2 I_O \max \left[1 + \frac{|V_O|}{V_I} \right]$$

$$L (\mu\text{H}) = \frac{V_I}{I_{PK}} t_{on} (\mu\text{s})$$

Choose L (50 to 500 μH), calculate t_{on} (25 to 150 μs)

$$C_T (\text{pF}) \approx 12 t_{on} (\mu\text{s})$$

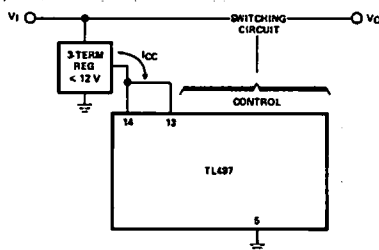
$$R_2 = (V_O - 1.2) \text{ k}\Omega$$

$$R_{CL} = \frac{0.5 \text{ V}}{I_{PK}}$$

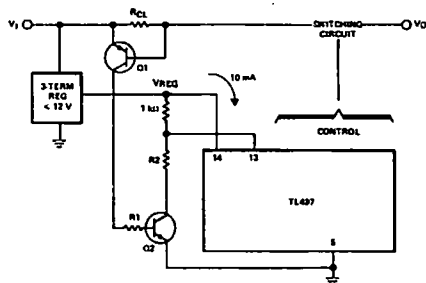
$$C_F (\mu\text{F}) \approx \frac{\left[\frac{V_I}{V_O} I_{PK} + I_O \right]}{V_{\text{ripple}} (\text{PK})}$$

* Use external catch-diode, e.g., 1N4001, when building an inverting supply with the TL497A.

FIGURE 3—INVERTING APPLICATIONS



EXTENDED INPUT CONFIGURATION WITHOUT CURRENT LIMIT



CURRENT LIMIT FOR EXTENDED INPUT CONFIGURATION

FIGURE 4—EXTENDED INPUT VOLTAGE RANGE ($V_I > 15 \text{ V}$)

DESIGN EQUATIONS

$$R_{CL} = \frac{V_{BE}(Q1)}{I_{\text{limit}} (\text{PK})}$$

$$R_1 = \frac{V_I}{I_B(Q2)}$$

$$R_2 = (V_{\text{reg}} - 1) 10 \text{ k}\Omega$$

- Completely Latched PWM Control Circuitry
- Totem-Pole Outputs for 200-mA Sink or Source Current
- Internal Circuitry Prohibits Double Pulse at Either Output
- Circuit Architecture Provides Easy Synchronization
- Low Bias Current
- Soft-Start and Dead-Time Control
- Under-Voltage Lockout Control for Low V_{CC} Conditions
- Internal Precision Reference Trimmed to 1%
- Feed-Forward Line Regulation Over 4-to-1 Input Range
- 20 kHz to 1 MHz Operation

description

The TLC498 incorporates on a single monolithic chip all the functions required for the construction of a pulse-width-modulation control circuit. Designed primarily for power supply control, the TLC498 contains an error amplifier, adjustable oscillator with line controlled ramp generator, latched PWM comparator with pulse-steering flip-flop, latched shut-down circuitry, on-chip 5.1-volt 1% precision reference regulator, soft-start control, and an undervoltage lockout.

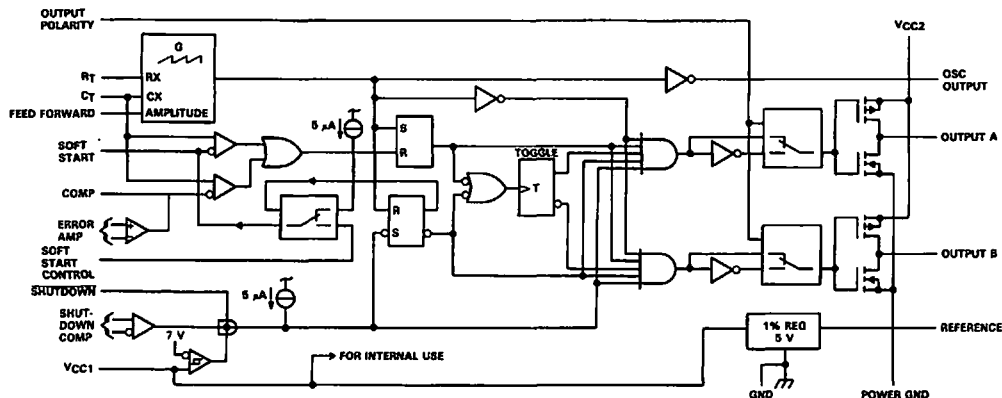
The architecture of the TLC498 prohibits the possibility of either output being pulsed twice during push-pull operation. The internal error amplifier exhibits a common-mode voltage range from -0.3 volts to $V_{CC} - 2$ volts.

The dual totem-pole output buffers provide a convenient drive for either power FET's or Bipolar transistors. Power and ground to the output buffers are isolated from the rest of the chip, enhancing noise immunity and providing single-ended output capability. The under-voltage lockout control circuitry senses low voltage conditions and locks the outputs off until the internal circuitry is operational.

The TLC498 is characterized for operation from 0°C to 70°C .

2

functional block diagram



PRODUCT PREVIEW

This document contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.

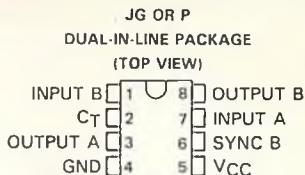
TEXAS INSTRUMENTS
INCORPORATED

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the first of these is the fact that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The second is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The third is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The fourth is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The fifth is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The sixth is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The seventh is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The eighth is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The ninth is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The tenth is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable.

- High Efficiency . . . 80% Typ
- Low Bias Current . . . 140 μ A
- Two Channels, Each with Output Voltage Adjustment
 Channel A: Output Voltage 2.5 V to 24 V
 Output Current 100 mA
 Channel B: Output Voltage 2.5 V to 24 V
 Output Current 1.8 mA
- Special Multifunctional Operation-Select Pin



description

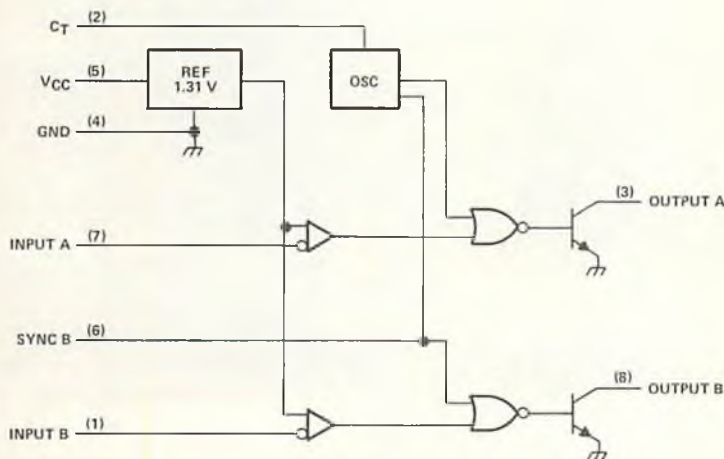
The TL580 is a monolithic, micropower, dual-switching regulator designed for use in battery applications. The output voltage of each channel is adjustable. Floating the special pin, SYNC B, causes Channel B to be synchronized to the oscillator in the same manner as Channel A. Shorting SYNC B to ground blocks the oscillator from Channel B, then Channel B becomes a single-input comparator for low-battery indicator detection.

Both Channel A and Channel B are referenced to a band-gap generator. An external capacitor on the C_T input (Pin 2) sets the oscillator frequency between 100 hertz and 160 kilohertz.

The TL580C can attain up to 80-percent efficiency while operating over a supply voltage range of 2.4 volts to 30 volts at an ultralow bias current of 140 microamperes.

The TL580C is characterized for operation from 0°C to 70°C.

functional block diagram (positive logic)



2

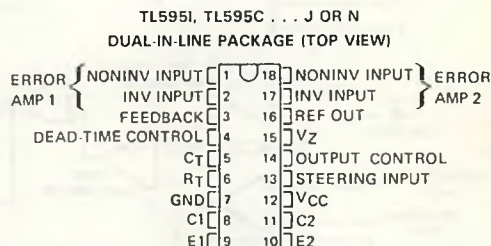
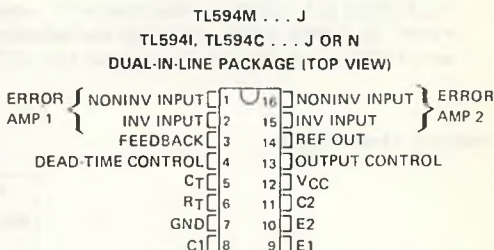
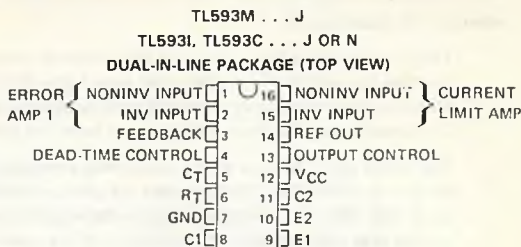
- Complete PWM Power Control Circuitry
- Uncommitted Outputs for 200-mA Sink or Source Current
- Output Control Selects Single-Ended or Push-Pull Operation
- Internal Circuitry Prohibits Double Pulse at Either Output
- Variable Dead-Time Provides Control Over Total Range
- Internal Regulator Provides a Stable 5-V Reference Supply Trimmed to 1%
- Circuit Architecture allows Easy Synchronization
- Under-Voltage Lockout for Low V_{CC} Conditions
- TL593 has Output Current-Limit Sensing
- TL595 has On-Chip 39-V Zener and External Control of Output Steering
- Improved Direct Replacements for TL493, TL494, and TL495

description

The TL593, TL594, and TL595 devices, each incorporate on a single monolithic chip all the functions required in the construction of a pulse-width-modulation control circuit. Designed primarily for power supply control, these devices offer the systems engineer the flexibility to tailor the power supply control circuitry to his application. The TL593, TL594, and TL595 are improved direct replacements for the TL493, TL494, and TL495.

The TL593 contains an error amplifier, current-limiting amplifier, an on-chip adjustable oscillator, a dead-time control comparator, pulse-steering control flip-flop, 5-volt regulator with a precision of 1%, an under-voltage lockout control circuit, and output control circuitry.

The error amplifier exhibits a common-mode voltage range from -0.3 volts to $V_{CC} - 2$ volts. The current-limit amplifier exhibits a common-mode voltage range from -0.3 volts to $V_{CC} - 6$ volts with an offset voltage of approximately 80 millivolts in series with the inverting input to ease circuit design requirements. The dead-time control comparator has a fixed offset that provides approximately 5% dead time when externally altered. The on-chip oscillator may be bypassed by terminating R_T (pin 6) to the reference output and providing a sawtooth input to C_T (pin 5), or it may be used to drive the common circuitry in synchronous multiple-rail power supplies.



DEVICE TYPES, SUFFIX VERSIONS, AND PACKAGES

	TL593	TL594	TL595
TL59-M	J	J	*
TL59-I	J,N	J,N	J,N
TL59-C	J,N	J,N	J,N

*These combinations are not defined by this data sheet.

FUNCTION TABLE

INPUTS		OUTPUT FUNCTION
OUTPUT CONTROL	STEERING INPUT (TL595 only)	
$V_I < 0.4$ V	Open	Single ended or parallel output
$V_I > 2.4$ V	Open	Normal push-pull operation
$V_I > 2.4$ V	$V_I < 0.4$ V	PWM Output at Q1
$V_I > 2.4$ V	$V_I < 2.4$ V	PWM Output at Q2

TYPES TL593, TL594, TL595 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

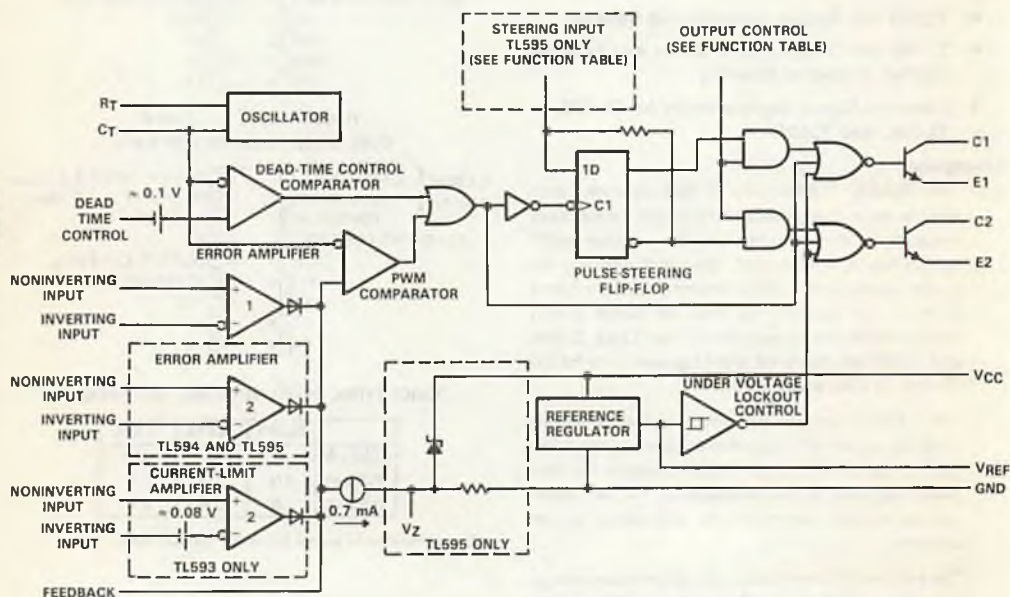
description (continued)

The uncommitted output transistors provide either common-emitter or emitter-follower output capability. Each device provides for push-pull or single-ended output operation with selection by means of the output-control function. The architecture of these devices prohibits the possibility of either output being pulsed twice during push-pull operation. The under-voltage lockout control circuit locks the outputs off until the internal circuitry is operational.

The TL593 and TL594 are similar except that an additional error amplifier is included in the TL594 instead of a current-limiting amplifier. The TL595 provides the identical functions found in the TL594. In addition, the TL595 also contains an on-chip 39-volt zener diode for high-voltage applications where V_{CC} is greater than 40 volts, and an output steering control that overrides the internal control of the pulse-steering flip-flop.

The TL593M and TL594M are characterized for operation over the full military temperature range from -55°C to 125°C . The TL593I, TL594I, and TL595I are characterized for operation from -25°C to 85°C . The TL593C, TL594C, and TL595C are characterized for operation from 0°C to 70°C .

functional block diagram



TYPES TL593, TL594, TL595 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

	TL593M TL594M	TL593I TL594I TL595I	TL593C TL594C TL595C	UNIT
Supply voltage, V_{CC} (see Note 10)	41	41	41	V
Amplifier input voltages	$V_{CC} + 0.3$	$V_{CC} + 0.3$	$V_{CC} + 0.3$	V
Collector output voltage	41	41	41	V
Collector output current	250	250	250	mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 2)	1000	1000	1000	mW
Operating free-air temperature range	-65 to 125	-25 to 85	0 to 70	°C
Storage temperature range	-65 to 150	-65 to 150	-65 to 150	°C
Lead temperature 1.6 mm (1/16 inch) from case for 60 seconds: J package	300	300	300	°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds: N package		260	260	°C

- NOTES: 1. All voltage values, except differential voltages, are with respect to the network ground terminal.
2. For operation above 25°C free-air temperature, refer to Dissipation Derating Table. In the J package, the TL593M and TL594M chips are alloy-mounted; TL593I, TL593C, TL594I, TL594C, TL595I, and TL595C chips are glass mounted.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE T_A
J (Alloy-Mounted Chip)	1000 mW	11.0 mW/°C	69°C
J (Glass-Mounted Chip)	1000 mW	8.2 mW/°C	28°C
N	1000 mW	9.2 mW	41°C

2

recommended operating conditions

	TL593M TL594M		TL593I TL594I TL595I		TL593C TL594C TL595C		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	7	40	7	40	7	40	V
Amplifier input voltages, V_I	-0.3	$V_{CC} - 2$	-0.3	$V_{CC} - 2$	-0.3	$V_{CC} - 2$	V
Collector output voltage, V_O		40		40		40	V
Collector output current (each transistor)		200		200		200	mA
Current into feedback terminal		0.3		0.3		0.3	mA
Timing capacitor, C_T	0.47	10 000	0.47	10 000	0.47	10 000	nF
Timing resistor, R_T	1.8	500	1.8	500	1.8	500	kΩ
Oscillator frequency	1	300	1	300	1	300	kHz
Operating free-air temperature, T_A	-65	125	-25	85	0	70	°C

TYPES TL593, TL594, TL595 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 15\text{ V}$, $f = 10\text{ kHz}$ (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS [†]	TL593M TL594M			TL593I, TL593C TL594I, TL594C TL595I, TL595C			UNIT
		MIN	TYP [‡]	MAX	MIN	TYP [‡]	MAX	
Output voltage (V_{ref})	$I_O = 1\text{ mA}$, $T_A = 25^\circ\text{C}$	4.95	5	5.05	4.95	5	5.05	V
Input regulation	$V_{CC} = 7\text{ V to }40\text{ V}$, $T_A = 25^\circ\text{C}$	2 25			2 25			mV
Output regulation	$I_O = 1\text{ to }10\text{ mA}$, $T_A = 25^\circ\text{C}$	14 35			14 35			mV
Output voltage change with temperature	$\Delta T_A = \text{MIN to MAX}$	0.2 1			0.2 1			%
Short-circuit output current [§]	$V_{ref} = 0$	10	35	60	10	35	50	mA

oscillator section, $C_T = 0.01\text{ }\mu\text{F}$, $R_T = 12\text{ k}\Omega$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS [†]	TL693M TL594M			TL593I, TL593C TL594I, TL594C TL595I, TL595C			UNIT
		MIN	TYP [‡]	MAX	MIN	TYP [‡]	MAX	
Frequency		10			10			kHz
Standard deviation of frequency [¶]	All values of V_{CC} , C_T , R_T , T_A constant	10			10			%
Frequency change with voltage	$V_{CC} = 7\text{ V to }40\text{ V}$, $T_A = 25^\circ\text{C}$	0.1			0.1			%
Frequency change with temperature	$\Delta T_A = \text{MIN to MAX}$	4			2			%

2 amplifier sections (see figure 1)

PARAMETER		TEST CONDITIONS		MIN	TYP [‡]	MAX	UNIT
Input offset voltage	Error	Feedback pin at 2.5 V		2		10	mV
	Current-limit (TL593 only)			80			
Input offset current		Feedback control at 2.5 V		25		250	nA
Input bias current		Feedback control at 2.5 V		0.2		1	μA
Common-mode input voltage range	Error	$V_{CC} = 7\text{ V to }40\text{ V}$		-0.3 to $V_{CC}-2$			V
	Current-limit (TL593 only)			-0.3 to $V_{CC}-6$			
Open-loop voltage amplification	Error	$\Delta V_O = 3\text{ V}$, $V_O = 0.5\text{ V to }3.5\text{ V}$		70		95	dB
	Current-limit (TL593 only)			90			
Unity-gain bandwidth				800			kHz
Common-mode rejection ratio	Error	$V_{CC} = 40\text{ V}$, $T_A = 25^\circ\text{C}$		65		80	dB
	Current-limit (TL593 only)			70			
Output sink current (pin 3)		$V_{ID} = -15\text{ mV to }-5\text{ V}$, Feedback control at 0.5 V		0.3		0.7	mA
Output source current (pin 3)		$V_{ID} = 15\text{ mV to }5\text{ V}$, Feedback at 3.5 V		-2			mA

[†]For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

[‡]All typical values except for parameter changes with temperature are at $T_A = 25^\circ\text{C}$.

[§]Duration of the short-circuit should not exceed one second.

[¶]Standard deviation is a measure of the statistical distribution about the mean as derived from the formula

$$\sigma = \sqrt{\frac{\sum_{n=1}^N (x_n - \bar{x})^2}{N-1}}$$

TYPES TL593, TL594, TL595

PULSE-WIDTH-MODULATION CONTROL CIRCUITS

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 15\text{ V}$, $f = 10\text{ kHz}$ (unless otherwise noted)

dead-time control section (see figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Input bias current (pin 4)	$V_I = 0\text{ to }5.25\text{ V}$		-2	-10	μA
Maximum duty cycle, each output	Dead-time control at 0 V	45			%
Input threshold voltage (pin 4)	Zero duty cycle		3	3.3	V
	Maximum duty cycle	0			

output section

PARAMETER	TEST CONDITIONS	TL593M TL594M			TL593I, TL593C TL594I, TL594C TL595I, TL595C			UNIT
		MIN	TYP [‡]	MAX	MIN	TYP [‡]	MAX	
Collector off-state current	$V_{CE} = 40\text{ V}$, $V_{CC} = 40\text{ V}$		2	100		2	100	μA
	$V_C = 15\text{ V}$, $V_E = 0\text{ V}$, $V_{CC} = 1\text{ to }3\text{ V}$, Dead-time and output control pins at 0 V		4	200		4	200	
Emitter off-state current	$V_{CC} = V_C = 40\text{ V}$, $V_E = 0$		-150			-100		μA
Collector-emitter saturation voltage	Common-emitter $V_E = 0$, $I_C = 200\text{ mA}$		1.1	1.5		1.1	1.3	V
Emitter-follower saturation voltage	$V_C = 15\text{ V}$, $I_E = -200\text{ mA}$		1.5	2.5		1.5	2.5	
Output control input current	$V_I = V_{ref}$			3.5			3.5	mA

pwm comparator section (see figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Input threshold voltage (pin 3)	Zero duty cycle		4	4.5	V
Input sink current (pin 3)	$V_{(pin\ 3)} = 0.5\text{ V}$	0.3	0.7		mA

under-voltage lockout section

PARAMETER	TEST CONDITIONS [†]	TL593M TL594M			TL593I, TL593C TL594I, TL594C TL595I, TL595C			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Threshold voltage	$T_A = 25^\circ\text{C}$			6			6	V
	$\Delta T_A = \text{MIN to MAX}$		3	6.9		3.5	6.9	
Hysteresis			30			100		mV

total device

PARAMETER	TEST CONDITIONS		MIN	TYP [‡]	MAX	UNIT
Standby supply current	Pin 6 at V_{ref} , All other inputs and outputs open	$V_{CC} = 15\text{ V}$		9	15	mA
		$V_{CC} = 40\text{ V}$		11	18	
Average supply current	Dead-time Control at 2 V, See Figure 2			12.4		mA

[†]For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

[‡]All typical values except for parameter changes with temperature are at $T_A = 25^\circ\text{C}$.

Hysteresis is the difference between the positive-going input threshold voltage and the negative-going input threshold voltage.

TYPES TL593, TL594, TL595
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

switching characteristics, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP [‡]	MAX	UNIT
Output voltage rise time	Common-emitter configuration,		100	200	ns
Output voltage fall time	See Figure 3		30	100	
Output voltage rise time	Emitter-follower configuration,		200	400	ns
Output voltage fall time	See Figure 4		45	100	

[‡]All typical values are at $T_A = 25^\circ\text{C}$.

PARAMETER MEASUREMENT INFORMATION

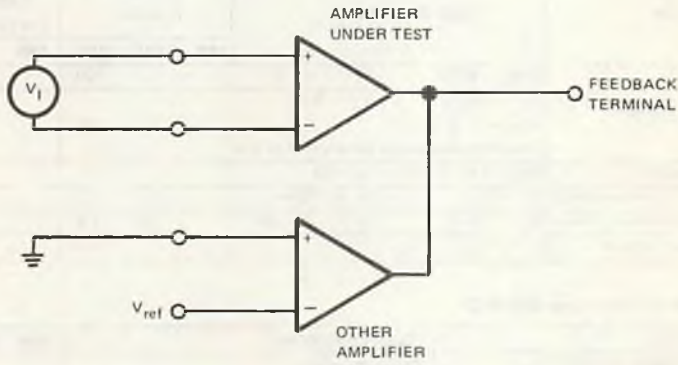


FIGURE 1 — AMPLIFIER CHARACTERISTICS

2

PARAMETER MEASUREMENT INFORMATION

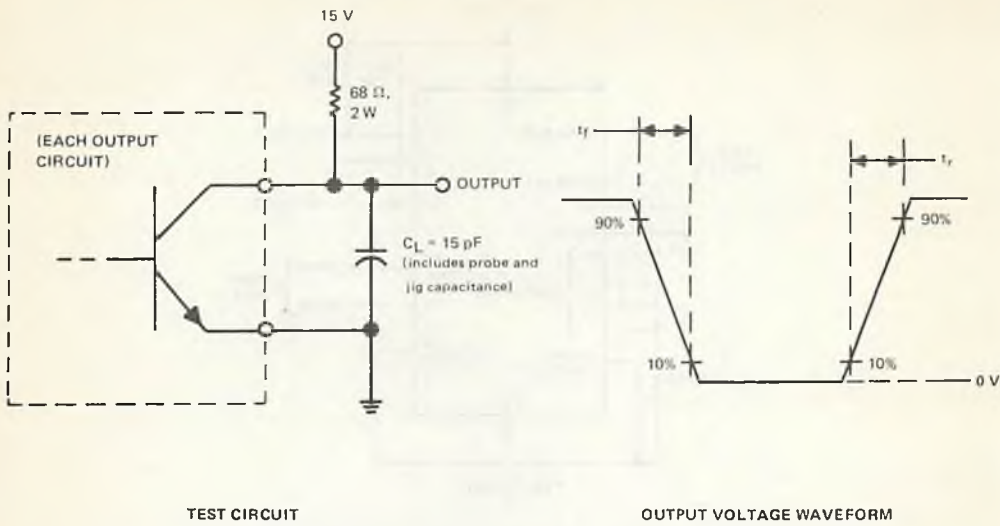


FIGURE 3—COMMON-EMITTER CONFIGURATION

2

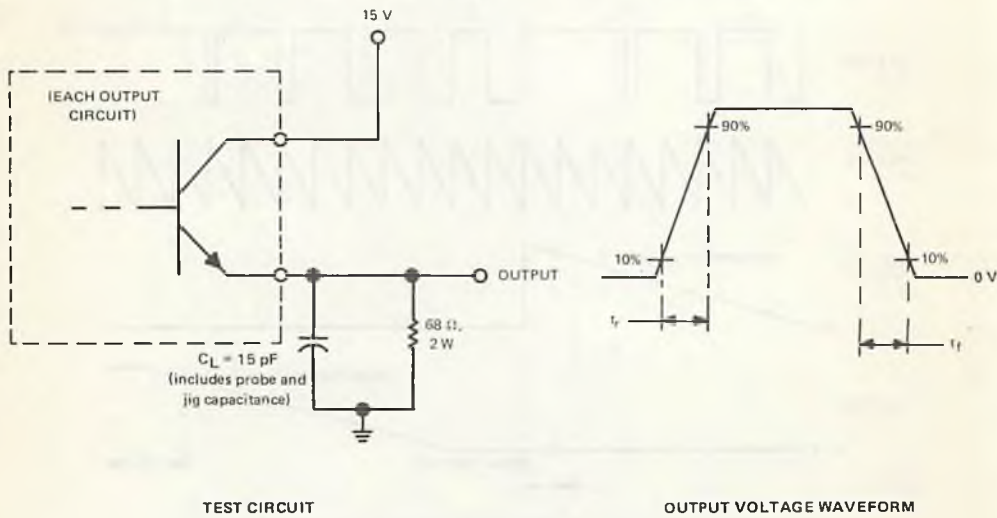


FIGURE 4—EMITTER-FOLLOWER CONFIGURATION

TYPICAL CHARACTERISTICS

OSCILLATOR FREQUENCY and
FREQUENCY VARIATION[†] vs
TIMING RESISTANCE

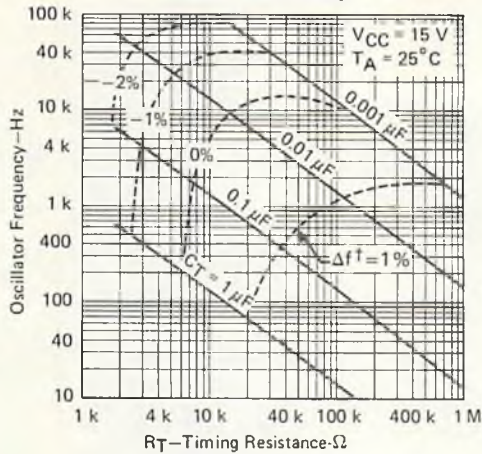


FIGURE 5

AMPLIFIER VOLTAGE AMPLIFICATION
vs
FREQUENCY

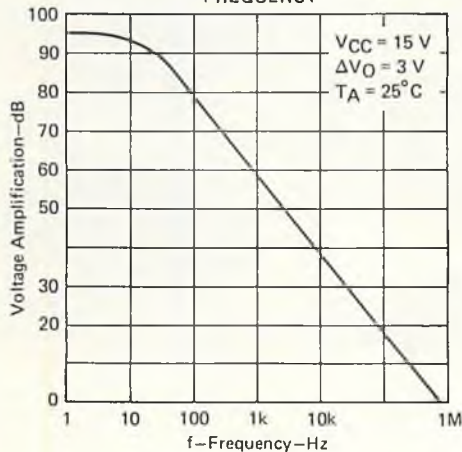


FIGURE 6

[†]Frequency variation (Δf) is the change in oscillator frequency that occurs over the full temperature range.

210000 100000 50000 0 0 50000 100000 210000

210000 100000 50000 0 0 50000 100000 210000



210000 100000 50000 0 0 50000 100000 210000

210000 100000 50000 0 0 50000 100000 210000

210000 100000 50000 0 0 50000 100000 210000



210000 100000 50000 0 0 50000 100000 210000

210000 100000 50000 0 0 50000 100000 210000

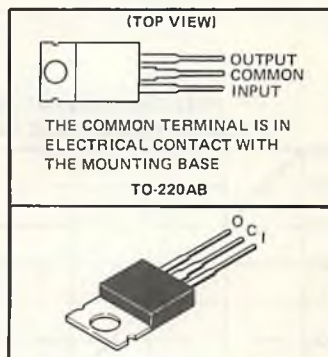
- $\pm 1\%$ Output tolerance at 25°C
- $\pm 2\%$ Output Tolerance Over Full Operating Range
- Thermal Shutdown
- Internal Short-Circuit Current Limiting
- Pinout Identical to $\mu\text{A}7800$ Series

NOMINAL OUTPUT VOLTAGE	REGULATOR
5 V	TL780-05C
12 V	TL780-12C
15 V	TL780-15C

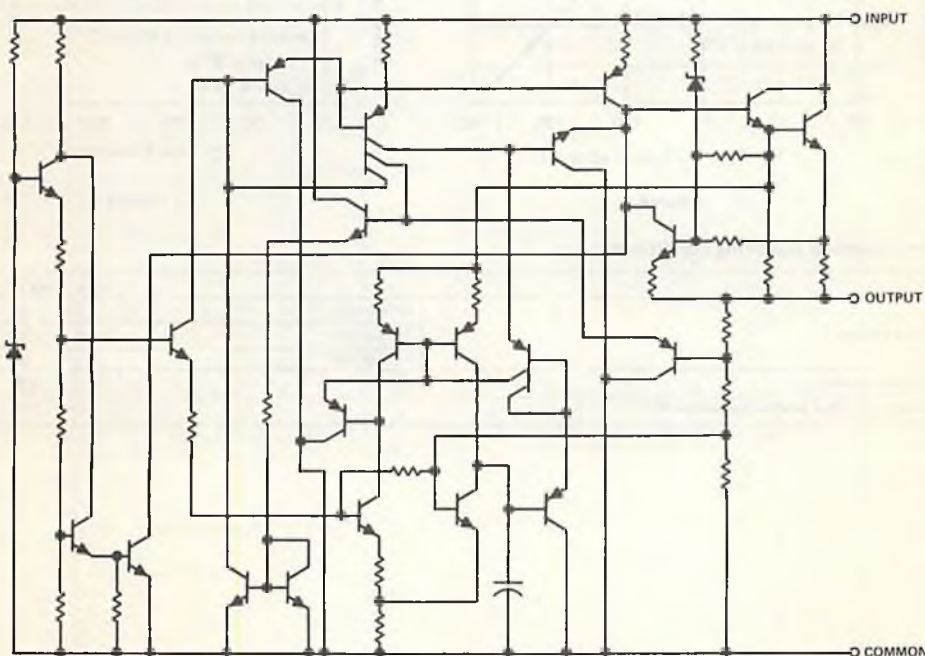
KC PACKAGE

description

Each fixed-voltage precision regulator in this series is capable of supplying 1.5 amperes of load current. A unique temperature-compensation technique coupled with an internally trimmed bandgap reference has resulted in improved accuracy when compared to other three-terminal regulators. Advanced layout techniques provide excellent line, load, and thermal regulation. The internal current limiting and thermal shutdown features make the devices essentially immune to overload.



schematic



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TEXAS INSTRUMENTS
INCORPORATED

POST OFFICE BOX 225012 • DALLAS, TEXAS 75265

SERIES TL780
POSITIVE VOLTAGE REGULATORS

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input voltage	35 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	15 W
Operating free-air, case, or virtual junction temperature range	0 to 150°C
Storage temperature range	-65 to 150°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds	260°C

Note 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Curves, Figure 1 and Figure 2.

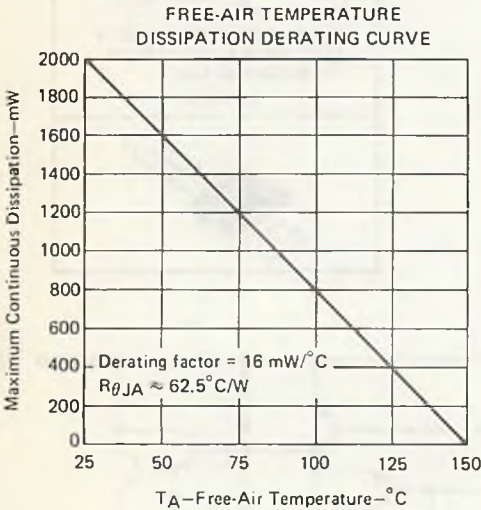


FIGURE 1

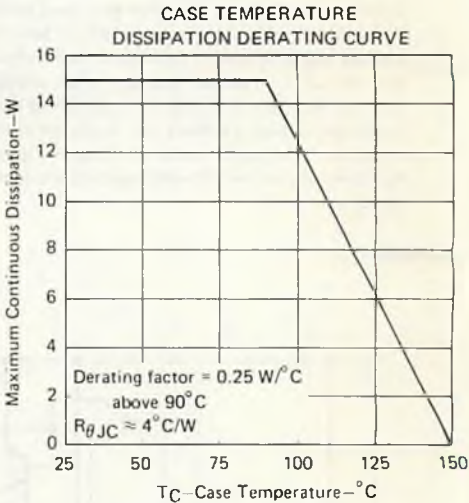


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	TL780-05C	7	25	V
	TL780-12C	14.5	30	
	TL780-15C	17.5	30	
Output current, I_O			1.5	A
Operating virtual junction temperature, T_J		0	125	°C

SERIES TL780

POSITIVE VOLTAGE REGULATORS

TL780-05C electrical characteristics at specified virtual junction temperature,
 $V_I = 10\text{ V}$, $I_O = 500\text{ mA}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT	
Output voltage	I _O = 5 mA to 1 A, V _I = 7 V to 20 V	P ≤ 15 W	25° C	4.95	5	5.05	V
			0° C to 125° C	4.9		5.1	
Input regulation	V _I = 7 V to 25 V	25° C		0.5	5	mV	
	V _I = 8 V to 12 V			0.5	5		
Ripple rejection	V _I = 8 V to 18 V, f = 120 Hz	0° C to 125° C	70	85		dB	
Output regulation	I _O = 5 mA to 1.5 A	25° C		4	25	mV	
	I _O = 250 mA to 750 mA			1.5	15		
Output resistance	f = 1 kHz	0° C to 125° C	0.0035			Ω	
Temperature coefficient of output voltage	I _O = 5 mA	0° C to 125° C	0.25			mV/° C	
Output noise voltage	f = 10 Hz to 100 kHz	25° C		75		μV	
Dropout voltage	I _O = 1 A	25° C		2		V	
Bias current		25° C		5	8	mA	
Bias current change	V _I = 7 V to 25 V	0° C to 125° C		0.7	1.3	mA	
	I _O = 5 mA to 1 A			0.03	0.5		
Short-circuit output current	V _I = 35 V	25° C		750		mA	
Peak output current		25° C		2.2		A	

TL780-12C electrical characteristics at specified virtual junction temperature,
 $V_I = 19\text{ V}$, $I_O = 500\text{ mA}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN TYP MAX			UNIT
Output voltage	I _O = 5 mA to 1 A, V _I = 14.5 V to 27 V	P ≤ 15 W	25°C	11.88	12 12.12	V
			0°C to 125°C	11.76	12.24	
Input regulation	V _I = 14.5 V to 30 V	25°C		1.2	12	mV
	V _I = 16 V to 22 V			1.2	12	
Ripple rejection	V _I = 15 V to 25 V	f = 120 Hz	0°C to 125°C	65	80	dB
Output regulation	I _O = 5 mA to 1.5 A	25°C		6.5	60	mV
	I _O = 250 mA to 750 mA			2.5	36	
Output resistance	f = 1 kHz		0°C to 125°C	0.0035		Ω
Temperature coefficient of output voltage	I _O = 5 mA		0°C to 125°C	0.6		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		25°C	180		μV
Dropout voltage	I _O = 1 A		25°C	2		V
Bias current			25°C	5.5 8		mA
Bias current change	V _I = 14.5 V to 30 V	0°C to 125°C		0.4	1.3	mA
	I _O = 5 mA to 1 A			0.03	0.5	
Short-circuit output current	V _I = 35 V		25°C	350		mA
Peak output current			25°C	2.2		A

† All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.22 μF . All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10\text{ ms}$, duty cycles $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

SERIES TL780

POSITIVE VOLTAGE REGULATORS

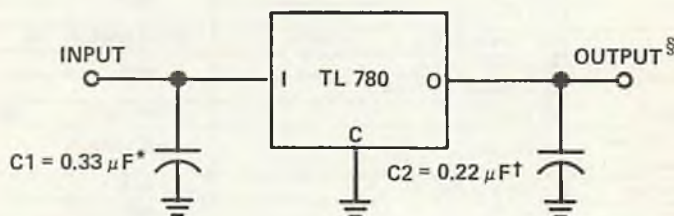
TL780-15C electrical characteristics at specified virtual junction temperature,
 $V_I = 23 \text{ V}$, $I_O = 500 \text{ mA}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	MIN	TYP	MAX	UNIT
Output voltage	$I_O = 5 \text{ mA to } 1 \text{ A}$, $V_I = 17.5 \text{ V to } 30 \text{ V}$ $P \leq 15 \text{ W}$	25°C	14.85	15	15.15
		0°C to 125°C	14.7		15.3
Input regulation	$V_I = 17.5 \text{ V to } 30 \text{ V}$	25°C	1.5	15	mV
	$V_I = 20 \text{ V to } 26 \text{ V}$		1.5	15	
Ripple rejection	$V_I = 18.5 \text{ V to } 28.5 \text{ V}$ $f = 120 \text{ Hz}$	0°C to 125°C	60	75	dB
Output regulation	$I_O = 5 \text{ mA to } 1.5 \text{ A}$	25°C	7	75	mV
	$I_O = 250 \text{ mA to } 750 \text{ mA}$		2.5	45	
Output resistance	$f = 1 \text{ kHz}$	0°C to 125°C	0.0035		Ω
Temperature coefficient of output voltage	$I_O = 5 \text{ mA}$	0°C to 125°C	0.62		mV/°C
Output noise voltage	$f = 10 \text{ Hz to } 100 \text{ kHz}$	25°C	225		μV
Dropout voltage	$I_O = 1 \text{ A}$	25°C	2		V
Bias current		25°C	5.5	8	mA
Bias current change	$V_I = 17.5 \text{ V to } 30 \text{ V}$	0°C to 125°C	0.4	1.3	mA
	$I_O = 5 \text{ mA to } 1 \text{ A}$		0.02	0.5	
Short-circuit output current	$V_I = 35 \text{ V}$	25°C	230		mA
Peak output current		25°C	2.2		A

† All characteristics are measured with a capacitor across the input of $0.33 \mu\text{F}$ and a capacitor across the output of $0.22 \mu\text{F}$. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10 \text{ ms}$, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

TYPICAL APPLICATION DATA

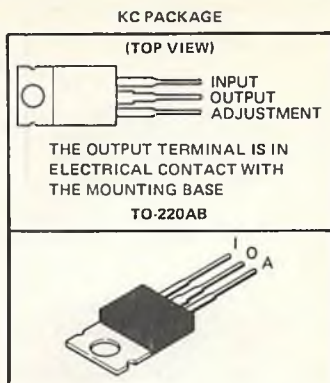


*C1 required if regulator is far from power supply filter.

†C2 not required for stability, however transient response is improved

§ Permanent damage can occur if output is pulled below ground.

- Adjustable Regulator for Precise Control of Voltage or Current
- Plug-In Replacement for Differential Voltage . . . 5.25 V to 200 V
- Input-to-Output Differential Voltage . . . 5.25 V to 200 V
- 1 A Output Current Capability
- Full Short-Circuit, Safe-Operating-Area, and Thermal Shutdown Protection
- 0.001% Typical Input Regulation
- 0.15% Typical Output Regulation
- 76 dB Typical Ripple Rejection
- Standard TO-220AB Package



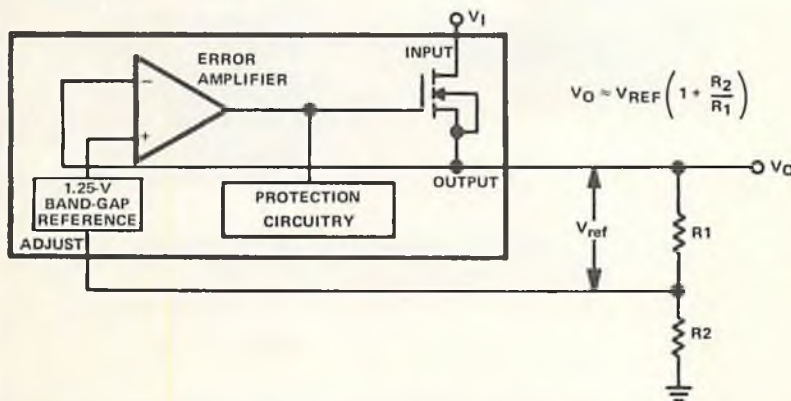
description

The TL783AC is an adjustable 3-terminal positive-voltage regulator with a DMOS output transistor capable of sourcing as much as 1 ampere. It is designed to be a direct plug-in replacement for the TL783C but offers a much larger differential voltage range, 5.25 volts to 200 volts. Excellent performance specifications — superior to those of most bipolar regulators — are achieved through circuit design and advanced layout techniques.

As a state-of-the-art regulator, the TL783AC combines standard bipolar circuitry with high-voltage double-diffused MOS transistors on one chip to yield a device capable of withstanding voltages far higher than standard bipolar integrated circuits. Because of its lack of secondary breakdown and thermal runaway characteristics usually associated with bipolar outputs, the TL783AC maintains full overload protection while operating at up to 200 volts from input to output. Other features of the device include current limiting, safe-operating-area (SOA) protection, and thermal shutdown. Even if the adjustment pin is inadvertently disconnected, the protection circuitry remains functional.

Only two external resistors are required to program the output voltage. An input bypass capacitor is necessary only when the regulator is situated far from the input filter. An output capacitor, although not required, will improve transient response and protection from instantaneous output short-circuits. Excellent ripple rejection can be achieved without a bypass capacitor at the adjustment terminal.

functional block diagram





- 1. The power system is a complex system of interconnected components.
- 2. The electric system is a complex system of interconnected components.
- 3. The power system is a complex system of interconnected components.
- 4. The electric system is a complex system of interconnected components.
- 5. The power system is a complex system of interconnected components.
- 6. The electric system is a complex system of interconnected components.
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- 8. The electric system is a complex system of interconnected components.
- 9. The power system is a complex system of interconnected components.
- 10. The electric system is a complex system of interconnected components.

2



- Output Adjustable From 1.25 V To 125-Volt
- 700 mA Output Current
- Full Short-Circuit, Safe-Operating-Area, and Thermal Shutdown Protection
- 0.001 %/V Typical Input Regulation
- 0.15% Typical Output Regulation
- 76 dB Typical Ripple Rejection
- Standard TO-220AB Package

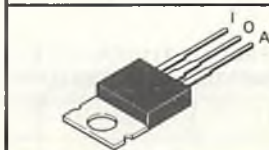
KC PACKAGE

(TOP VIEW)



THE OUTPUT TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



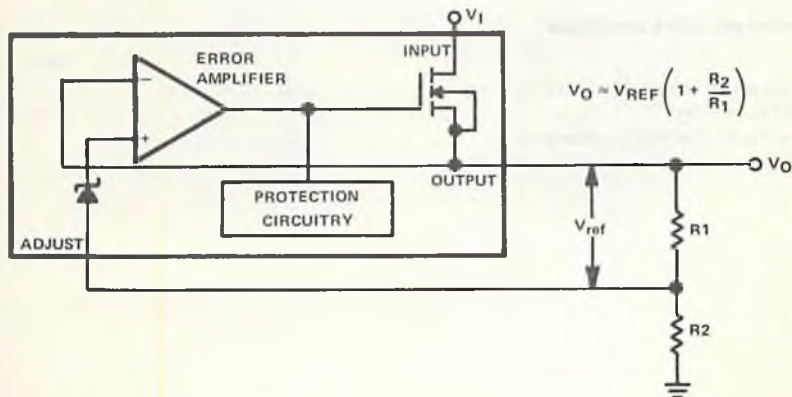
description

The TL783 is an adjustable 3-terminal positive-voltage regulator with an output range of 1.25 volts to 125 volts and a DMOS output transistor capable of sourcing more than 700 milliamperes. It is designed for use in high-voltage applications where standard bipolar regulators cannot be used. Excellent performance specifications . . . superior to those of most bipolar regulators . . . are achieved through circuit design and advanced layout techniques.

As a state-of-the-art regulator, the TL783 combines standard bipolar circuitry with high-voltage double-diffused MOS transistors on one chip to yield a device capable of withstanding voltages far higher than standard bipolar integrated circuits. Because of its lack of secondary breakdown and thermal runaway characteristics usually associated with bipolar outputs, the TL783 maintains full overload protection while operating at up to 125 volts from input to output. Other features of the device include current limiting, safe-operating-area (SOA) protection, and thermal shutdown. Even if the adjustment pin is inadvertently disconnected, the protection circuitry remains functional.

Only two external resistors are required to program the output voltage. An input bypass capacitor is necessary only when the regulator is situated far from the input filter. An output capacitor, although not required, will improve transient response and protection from instantaneous output short-circuits. Excellent ripple rejection can be achieved without a bypass capacitor at the adjustment terminal.

functional block diagram



TYPE TL783C

HIGH-VOLTAGE ADJUSTABLE REGULATOR

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input-to-output differential voltage, $V_I - V_O$	125 V
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	20 W
Operating free-air, case, or virtual junction temperature range	0°C to 150°C
Lead temperature 1/16 inch (1,6 mm) from case for 10 seconds	260°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to the dissipation derating curves, Figures 1 and 2.

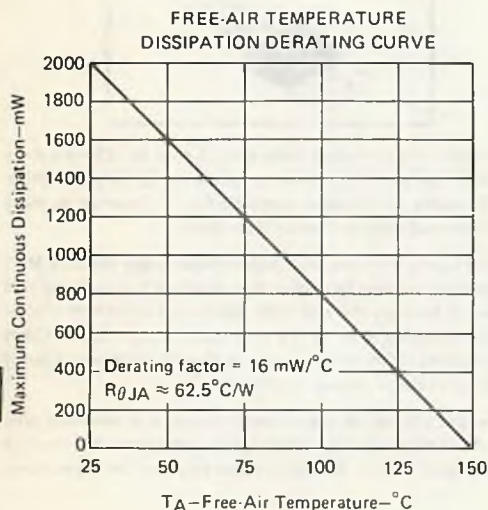


FIGURE 1

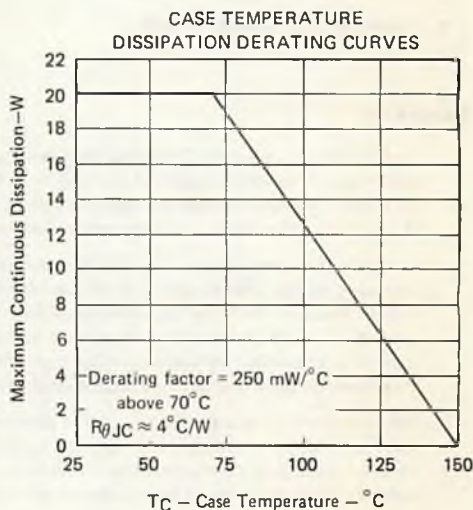


FIGURE 2

recommended operating conditions

	MIN	MAX	UNIT
Input-to-output voltage differential, $V_I - V_O$		125	V
Output current, I_O	15	700	mA
Operating virtual junction temperature, T_J	0	125	°C

TYPE TL783C HIGH-VOLTAGE ADJUSTABLE REGULATOR

electrical characteristics at $V_I - V_O = 25\text{ V}$, $I_O = 0.5\text{ A}$, $T_J = 0^\circ\text{C}$ to 125°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Input regulation‡	$V_I - V_O = 20\text{ V}$ to 125 V	$T_J = 25^\circ\text{C}$ $T_J = 0^\circ\text{C}$ to 125°C		0.001 0.004	0.01 0.02	%/V
Ripple rejection	$\Delta V_{I(p-p)} = 10\text{ V}$, $V_O = 10\text{ V}$, $f = 120\text{ Hz}$		66	76		dB
Output regulation	$I_O = 15\text{ mA}$ to 700 mA , $T_J = 25^\circ\text{C}$	$V_O \leq 5\text{ V}$		7.5	25	mV
		$V_O > 5\text{ V}$		0.15	0.5	%
	$I_O = 15\text{ mA}$ to 700 mA	$V_O \leq 5\text{ V}$		20	70	mV
		$V_O > 5\text{ V}$		0.3	1.5	%
Output voltage change with temperature				0.4		%
Output voltage long-term drift	1000 h at $T_J = 125^\circ\text{C}$, See Note 2	$V_I - V_O = 125\text{ V}$		0.2		%
Output noise voltage	$f = 10\text{ Hz}$ to 10 kHz , $T_J = 25^\circ\text{C}$			0.003		%
Minimum output current to maintain regulation	$V_I - V_O = 125\text{ V}$				15	mA
Peak output current	$V_I - V_O = 25\text{ V}$, $t = 1\text{ ms}$			1100		mA
	$V_I - V_O = 15\text{ V}$, $t = 30\text{ ms}$			715		
	$V_I - V_O = 25\text{ V}$, $t = 30\text{ ms}$		700	900		
	$V_I - V_O = 125\text{ V}$, $t = 30\text{ ms}$		100	250		
Adjustment-terminal current				83	110	μA
Change in adjustment-terminal current	$V_I - V_O = 15\text{ V}$ to 125 V , $I_O = 15\text{ mA}$ to 700 mA , $P \leq \text{rated dissipation}$			0.5	5	μA
Reference voltage (output to ADJ)	$V_I - V_O = 10\text{ V}$ to 125 V , $I_O = 15\text{ mA}$ to 700 mA , $P \leq \text{rated dissipation}$		1.2	1.27	1.3	V

† All characteristics except noise voltage and ripple rejection are measured using pulse techniques ($t_W \leq 10\text{ ms}$, duty cycle $\leq 5\%$) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.

‡ Input regulation is expressed here as the percentage change in output voltage per 1-volt change at the input.

NOTE 2: Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPE TL783C

HIGH-VOLTAGE ADJUSTABLE REGULATOR

TYPICAL CHARACTERISTICS

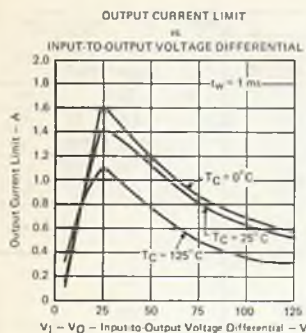


FIGURE 3

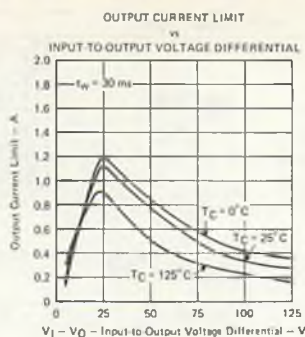


FIGURE 4

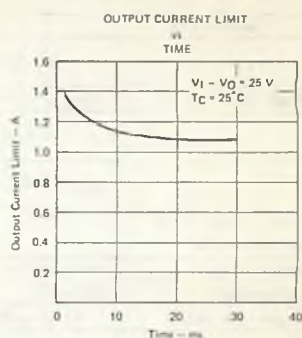


FIGURE 5

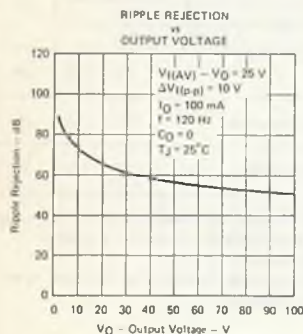


FIGURE 6

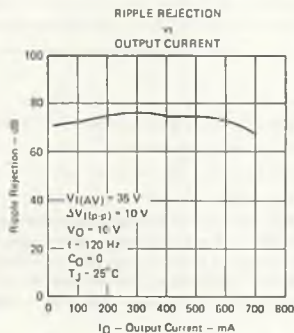


FIGURE 7

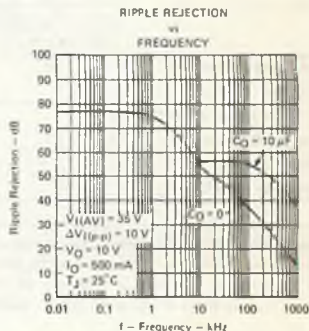


FIGURE 8

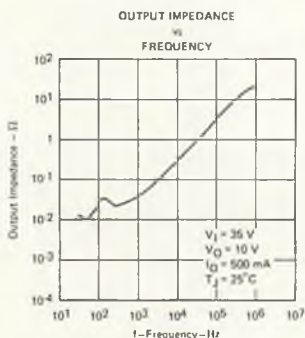


FIGURE 9

TYPE TL783C HIGH-VOLTAGE ADJUSTABLE REGULATOR

TYPICAL CHARACTERISTICS

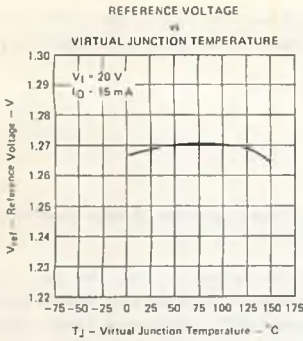


FIGURE 10

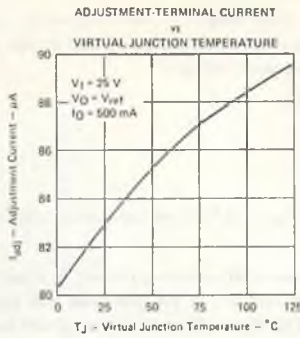


FIGURE 11

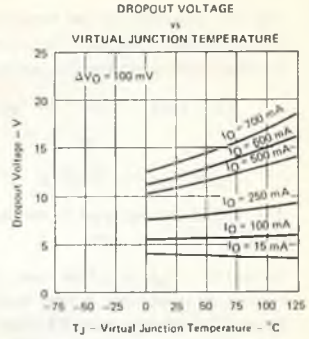


FIGURE 12

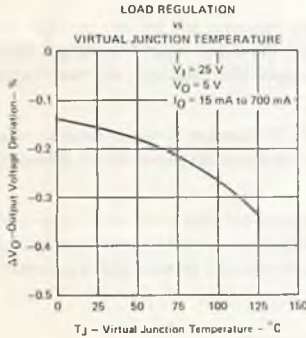


FIGURE 13

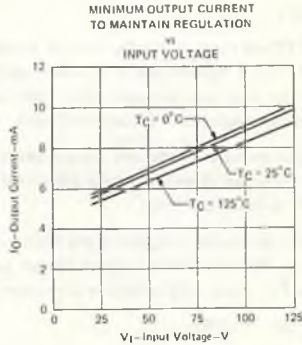


FIGURE 14

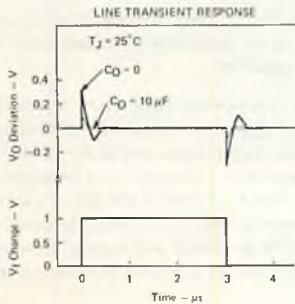


FIGURE 15

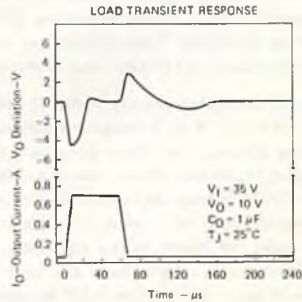


FIGURE 16

TYPE TL783C

HIGH-VOLTAGE ADJUSTABLE REGULATOR

DESIGN CONSIDERATIONS

The internal reference (see functional block diagram) is used to generate 1.25 volts nominal (V_{ref}) between the output and adjustment terminals. This voltage is developed across R1 and causes a constant current to flow through R1 and the programming resistor R2, giving an output voltage of:

$$V_O = V_{ref} (1 + R2/R1) + I_{adj} (R2)$$

or

$$V_O \approx V_{ref} (1 + R2/R1).$$

The TL783 was designed to minimize I_{adj} and maintain consistency over line and load variations, thereby minimizing the $I_{adj} (R2)$ error term.

To maintain I_{adj} at a low level, all quiescent operating current is returned to the output terminal. This quiescent current must be sunk by the external load and is the minimum load current necessary to prevent the output from rising. The recommended R1 value of 82 ohms will provide a minimum load current of 15 milliamperes. Larger values may be used if the input-to-output differential voltage is less than 125 volts (see minimum operating current curve) or if the load will sink some portion of the minimum current.

Bypass capacitors

The TL783 regulator is stable without bypass capacitors; however, any regulator will become unstable with certain values of output capacitance if an input capacitor is not used. Therefore, the use of input bypassing is recommended whenever the regulator is located more than four inches from the power-supply filter capacitor. A 1-microfarad tantalum or electrolytic capacitor is usually sufficient.

Adjustment-terminal capacitors are not recommended for use on the TL783 because they can seriously degrade load transient response as well as create a need for extra protection circuitry. Excellent ripple rejection is presently achieved without this added capacitor.

Due to the relatively low gain of the MOS output stage, output voltage drop-out may occur under large load transient conditions. Addition of an output bypass capacitor will greatly enhance load transient response as well as prevent drop-out. For most applications it is recommended that an output bypass capacitor be used with a minimum value of:

$$C_O (\mu f) = 15/V_O$$

Larger values will provide proportionally better transient response characteristics.

Protection circuitry

The TL783 regulator includes built-in protection circuitry capable of guarding the device against most overload conditions encountered in normal operation. These protective features are current limiting, safe-operating-area protection, and thermal shutdown. These circuits are meant to protect the device under occasional fault conditions only. Continuous operation in the current limit or thermal shutdown mode is not recommended.

The internal protection circuits of the TL783 will protect the device up to maximum rated V_I as long as certain precautions are taken. If V_I is instantaneously switched on, transients exceeding maximum input ratings may occur, which can destroy the regulator. These are usually caused by lead inductance and bypass capacitors causing a ringing voltage on the input. In addition, if rise times in excess of 10 V/ns are applied to the input, a parasitic n-p-n transistor in parallel with the DMOS output can be turned on causing the device to fail. If the device is operated over 50 volts and the input is switched on rather than ramped on, a low-Q capacitor, such as a tantalum or electrolytic should be used rather than ceramic, paper, or plastic bypass capacitors. A dissipation factor of 0.015 or greater will usually provide adequate damping to suppress ringing. Normally, no problems will occur if the input voltage is allowed to ramp upward through the action of an ac line rectifier and filter network.

TYPE TL783C HIGH-VOLTAGE ADJUSTABLE REGULATOR

Similarly, if an instantaneous short circuit is applied to the outputs, both ringing and excessive fall times can result. A tantalum or electrolytic bypass capacitor is recommended to eliminate this problem. However, if a large output capacitor is used and the input is shorted, addition of a protection diode may be necessary to prevent capacitor discharge through the regulator. The amount of discharge current delivered is dependent on output voltage, size of capacitor, and fall time of V_I . A protective diode (see Figure 17) is required only for capacitance values greater than

$$C_O (\mu f) = 3 \times 10^4 / (V_O)^2.$$

Care should always be taken to prevent insertion of regulators into a socket with power on. Power should be turned off before removing or inserting regulators.

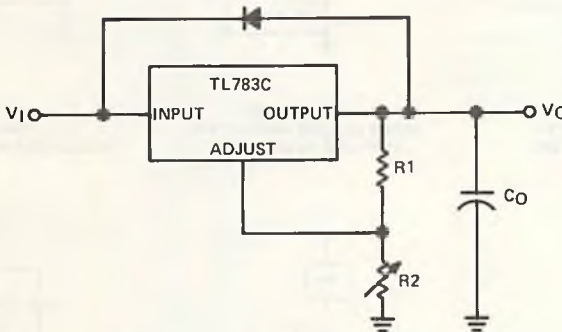


FIGURE 17—REGULATOR WITH PROTECTIVE DIODE

2

Load regulation

The current set resistor (R_1) should be located close to the regulator output terminal rather than near the load. This eliminates long line drops from being amplified through the action of R_1 and R_2 to degrade load regulation. To provide remote ground sensing, R_2 should be near the load ground.

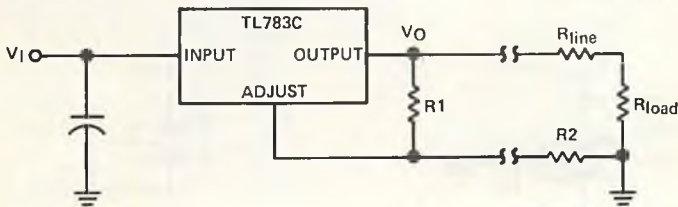


FIGURE 18—REGULATOR WITH CURRENT-SET RESISTOR

TYPE TL783C

HIGH-VOLTAGE ADJUSTABLE REGULATOR

TYPICAL APPLICATION DATA

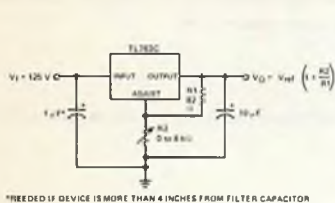


FIGURE 19—1.25-V TO 115-V ADJUSTABLE REGULATOR

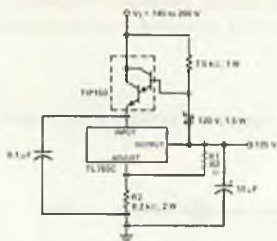


FIGURE 20—125-V SHORT-CIRCUIT-PROTECTED OFF-LINE REGULATOR

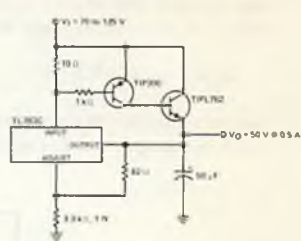


FIGURE 21—50-V REGULATOR WITH CURRENT BOOST

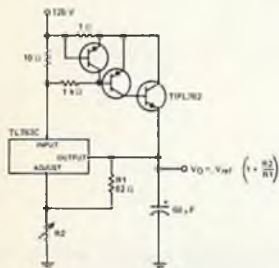


FIGURE 22—ADJUSTABLE REGULATOR WITH CURRENT BOOST AND CURRENT LIMIT

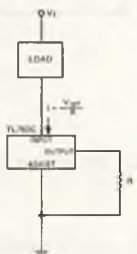


FIGURE 23—CURRENT-SINKING REGULATOR

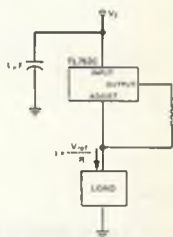


FIGURE 24—CURRENT-SOURCING REGULATOR

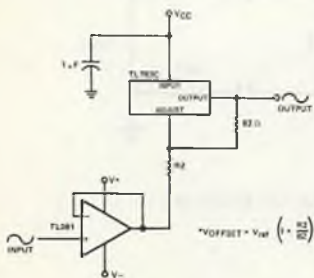


FIGURE 25—HIGH-VOLTAGE UNITY-GAIN OFFSET AMPLIFIER

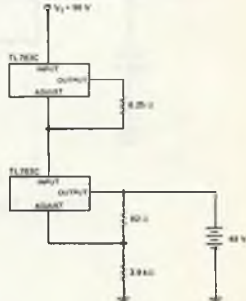
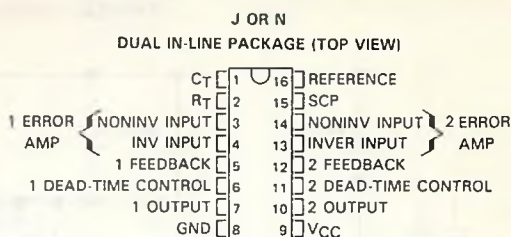


FIGURE 26—48-V, 200-mA FLOAT CHARGER

- Complete PWM Power Control Circuitry
- Completely Synchronized Operation
- Internal Under-Voltage Lockout Protection
- Wide Supply Voltage Range
- Internal Short-Circuit Protection
- Oscillator Frequency . . . 500 kHz Max
- Variable Dead Time Provides Control Over Total Range
- Internal Regulator Provides A Stable 2.5-V Reference Supply



description

The TL1451 incorporates on a single monolithic chip all the functions required in the construction of two pulse-width-modulation control circuits. Designed primarily for power supply control, the TL1451 contains an on-chip 2.5-volt regulator, two error amplifiers, an adjustable oscillator, two dead-time comparators, under-voltage lockout circuitry, and dual common-emitter output transistor circuits.

The uncommitted output transistors provide common-emitter output capability for each controller. The internal amplifiers exhibit a common-mode voltage range from 0.4 volts to 1.5 volts. The dead-time control comparator has no offset unless externally altered and may be used to provide 0% to 100% dead time. The on-chip oscillator may be operated by terminating R_T (pin 2) and C_T (pin 1). During low V_{CC} conditions, the under-voltage lockout control circuit feature locks the outputs off until the internal circuitry is operational.

The TL1451 is characterized for operation from -20°C to 85°C .

recommended operating conditions

	MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}	3.6		40	V
High-level output voltage, V_{OH}			40	V
High-level output current, I_{OH}			20	mA
Error amplifier common-mode input voltage, V_{IC}	0.4		1.5	V
Input voltage range at dead-time terminal	1.4		2.05	V
Input current at feedback terminal			-50	μA
Timing capacitor, C_T	0.15		15	μF
Timing resistor, R_T		5	50	k Ω
Oscillator frequency, f_{osc}		1	500	kHz
Operating free-air temperature, T_A	-20		85	$^{\circ}\text{C}$

2

PRODUCT PREVIEW

This document contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.

TEXAS INSTRUMENTS
INCORPORATED

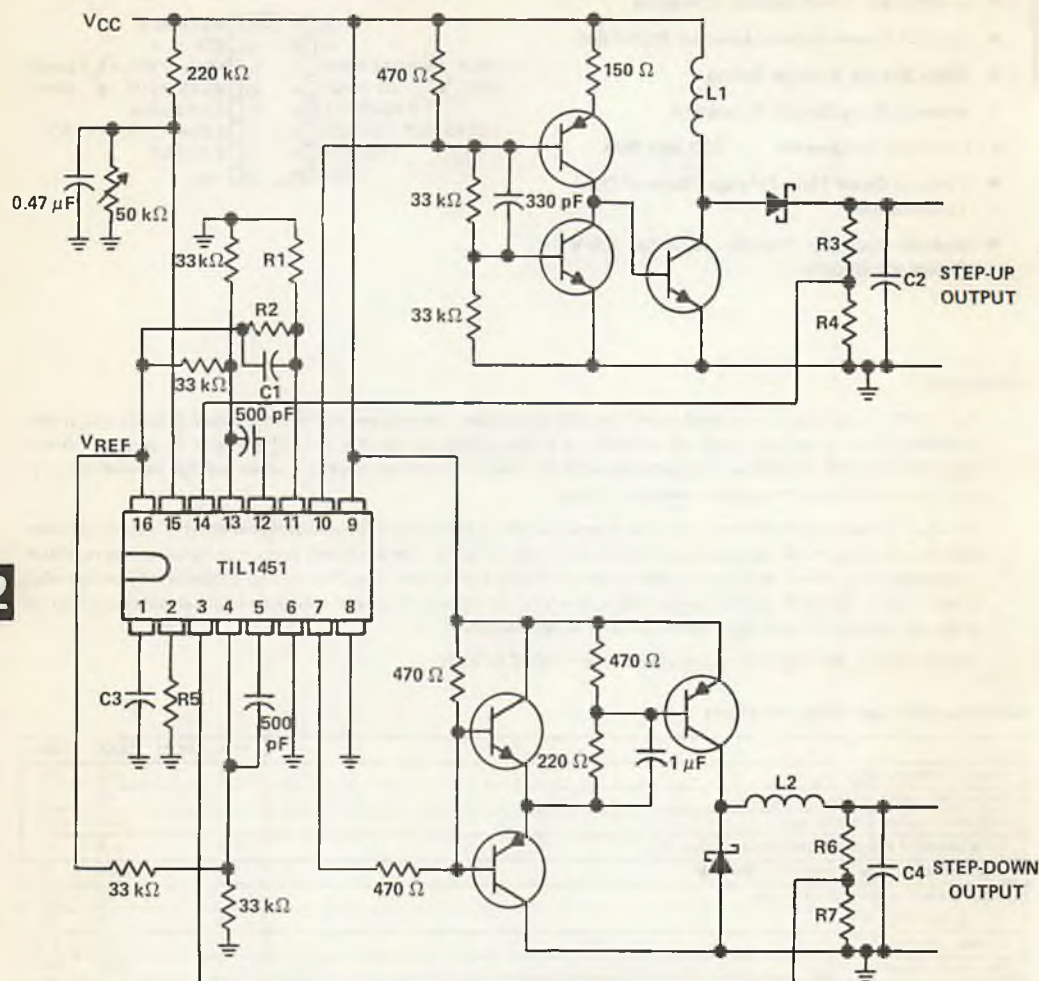
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TYPE TL1451C

DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUIT

TYPICAL APPLICATION DATA

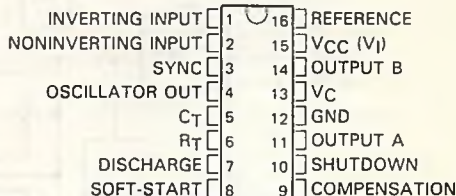


Values for R1 through R7, C1 through C4, and L1 and L2 depend upon individual application.

- Complete PWM Power Control Circuitry
- 8-Volt to 35-Volt Operation
- 5.1-Volt Reference Trimmed to $\pm 1\%$
- Frequency Range . . . 100 Hz to 500 Hz
- Adjustable Deadtime Control
- Under-Voltage Lockout for Low V_{CC} Conditions
- Latched PWM Prevents Multiple Pulses
- Dual Sink or Source Output Drivers
- Improved Direct Replacements for Silicon General SG1525A/SG1527A Series

TL1525A, TL1527A. . . J
TL2525A, TL2527A. . . J OR N
TL3525A, TL3527A. . . J OR N

DUAL-IN-LINE PACKAGE
(TOP VIEW)



output logic

TL1525A, TL2525A, TL3525A . . . NOR
TL1527A, TL2527A, TL3527A . . . OR

description

The TL1525A/TL1527A series of pulse-width modulation integrated circuits are designed to offer improved performance and lower external parts count when used to implement various types of switching power supplies. Each device includes an on-chip 5.1-volt reference, error amplifier, programmable oscillator, pulse-steering flip-flop, a latched comparator under-voltage lockout, shutdown circuitry, and complementary source or sink outputs. The on-chip 5.1-volt reference is trimmed to $\pm 1\%$ initial accuracy that serves as a reference output as well as supplying the internal regulator control circuitry. The input common-mode range of the error amplifier includes the reference voltage, which eliminates the need for external divider resistors.

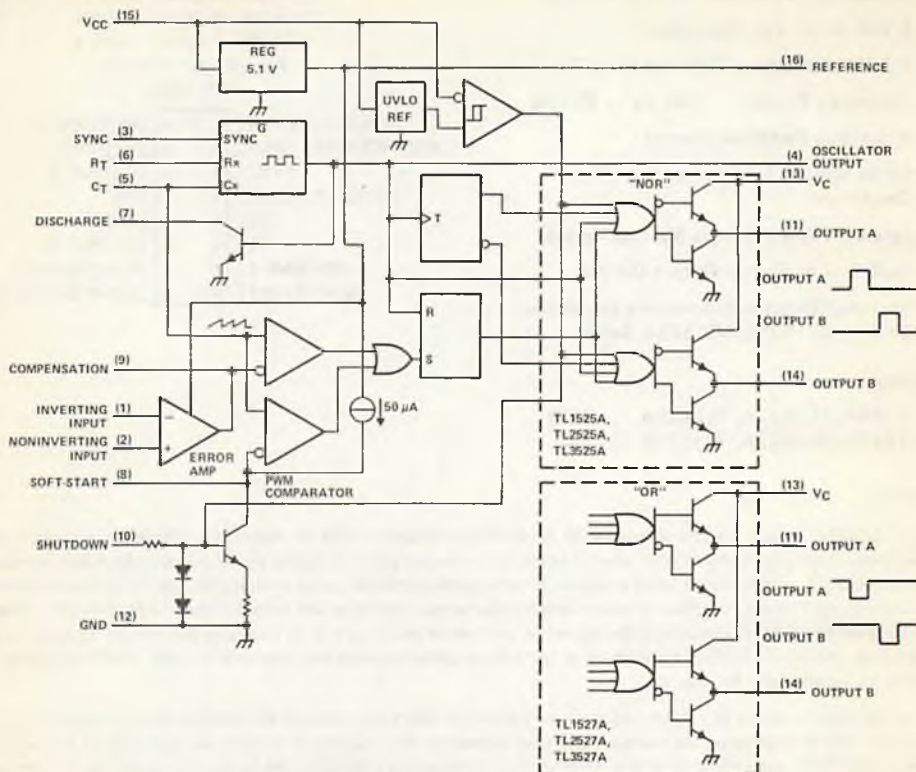
The oscillator operates at a fixed frequency determined by one timing resistor R_T and one timing capacitor C_T . The timing resistor establishes the constant charging current for C_T , resulting in a linear voltage ramp at C_T , which is fed to the PWM comparator providing linear control of the output pulse duration by the error amplifier. A Sync input to the oscillator allows for external synchronization or for multiple units to be slaved together. A single external resistor between the C_T pin and the Discharge pin provides a wide range of dead-time adjustment. These devices also feature built-in soft-start circuitry that requires only an external timing capacitor. The Shutdown pin controls both the soft-start and the output drivers, and provides instantaneous turn-off with soft-start recycle for slow turn-on. The soft-start and output driver circuitry are also controlled by the under-voltage lockout circuit, which, during low-input supply voltage of less than that required for normal operation, keeps the soft-start capacitor discharged and the output drivers off.

Another unique feature is the S/R latch following the PWM comparator. This feature enables the output drivers to be turned off any time the PWM pulse is terminated; The latch is reset with each clock pulse. However, the PWM outputs will remain turned off for the duration of the period if the PWM comparator output is in a low-level state. The TL2525A, and TL3525A output stages feature NOR logic, which results in a low output for an off-state. The TL1527A, TL2527A, and TL3527A output stages feature OR logic, which results in a high-level output for an off-state. The output stages are totem-pole designs capable of sourcing or sinking 200 milliamperes of output current.

The TL1525A and TL1527A are characterized for operation over the full military temperature range of -55°C to 125°C . The TL2525A and TL2527A are characterized for operation from -25°C to 85°C . The TL3525A and TL3527A are characterized for operation for 0°C to 70°C .

TYPES TL1525A, TL1527A, TL2525A, TL2527A, TL3525A, TL3527A PULSE-WIDTH MODULATION CONTROLLERS

functional block diagram (positive logic)



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1)	40 V
Collector voltage, V_C	40 V
Logic input voltage range sync and shutdown	-0.3 V to 5.5 V
Analog input voltage range error amplifier inputs	-0.3 V to V_{CC}
Output current, I_O	500 mA
Reference output current, I_{REF}	50 mA
Current through C_T terminal	-5 mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 2)	1000 mW
Operating free-air temperature range: TL1525A, TL1527A	-55°C to 125°C
TL2525A, TL2527A	-25°C to 85°C
TL3525A, TL3527A	0°C to 70°C
Operating virtual junction temperature range	0°C to 150°C
Storage temperature range	-65°C to 150°C
Lead temperature 1.6 mm (1/16 inch) from case for 60 seconds: J Package	300°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds: N Package	260°C

NOTES: 1. All voltage values are with respect to network ground terminal.

2. For operating above 25°C free-air temperature, see Dissipation Derating Curves, Figures 1 and 2. In the J package, TL1525A and TL1527A chips are alloy mounted; TL2525A, TL2527A, TL3525A, and TL3527A chips are epoxy mounted.

TYPES TL1525A, TL1527A, TL2525A, TL2527A, TL3525A, TL3527A PULSE-WIDTH MODULATION CONTROLLERS

J PACKAGE FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

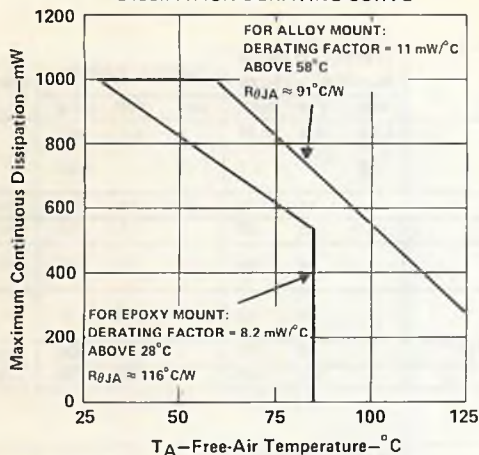


FIGURE 1

N PACKAGE FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

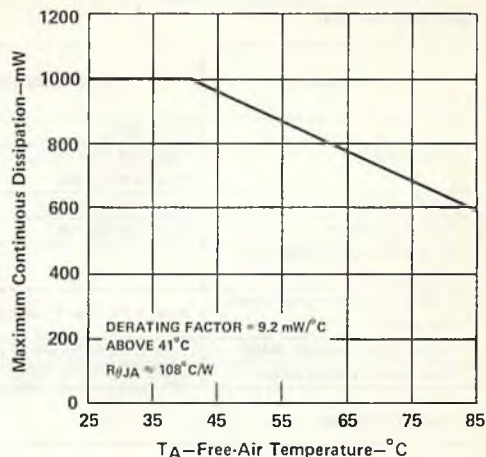


FIGURE 2

recommended operating conditions

PARAMETER	TL1525A, TL1527A		TL2525A, TL2527A		TL3525A, TL3527A		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	8	35	8	35	8	35	V
Collector voltage, V_C	4.5	35	4.5	35	4.5	35	V
Output current, I_O	Steady state		0	±100	0	±100	mA
	Peak		0	±400	0	±400	
Reference output current, I_{REF}	0	20	0	20	0	20	mA
Oscillator frequency range	100	500	100	500	100	500	kHz
Timing resistor, R_T	2	150	2	150	2	150	kΩ
Timing capacitor, C_T	0.001	0.1	0.001	0.1	0.001	0.1	μF
Dead-time resistor, R_D	0	500	0	500	0	500	Ω
Operating free-air temperature range, T_A	-55	125	-25	85	0	70	°C

TYPES TL1525A, TL1527A, TL2525A, TL2527A, TL3525A, TL3527A PULSE-WIDTH MODULATION CONTROLLERS

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 20\text{ V}$
(unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS	TL1525A, TL1527A TL2525A, TL2527A			TL3525A, TL3527A			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$T_J = 25^\circ\text{C}$	5.05	5.1	5.15	5	5.1	5.2	V
	$V_{CC} = 8\text{ V to }35\text{ V}$, $I_O = 0\text{ to }20\text{ mA}$	5		5.2	4.95		5.25	
Input regulation	$V_{CC} = 8\text{ V to }35\text{ V}$		14	20		14	20	mV
Output regulation	$I_O = 0\text{ to }20\text{ mA}$		5	50		5	50	mV
Output voltage change with temperature			24	50		24	50	mV
Output voltage long-term drift (see Note 3)	After 1000 h at $T_J = 125^\circ\text{C}$		25	50		25	50	mV
Output noise voltage (RMS)	$f = 10\text{ Hz to }10\text{ kHz}$, $T_J = 25^\circ\text{C}$		40	200		40	200	μV
Short-circuit output current	$V_O = 0\text{ V}$, $T_J = 25^\circ\text{C}$		80	100		80	100	mA

oscillator section

PARAMETER	TEST CONDITIONS	TL1525A, TL1527A TL2525A, TL2527A			TL3525A, TL3527A			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Maximum frequency	$R_T = 2\text{ k}\Omega$, $C_T = 1\text{ nF}$	400			400			kHz
Minimum frequency	$R_T = 150\text{ k}\Omega$, $C_T = 0.1\text{ }\mu\text{F}$			100			100	Hz
Initial frequency error	$R_T = 3.6\text{ k}\Omega$, $R_D = 0\text{ }\Omega$, $C_T = 0.1\text{ }\mu\text{F}$, $f = 40\text{ kHz}$, $T_A = 25^\circ\text{C}$		$\pm 2\%$	$\pm 6\%$		$\pm 2\%$	$\pm 6\%$	
Frequency change with supply voltage	$V_{CC} = 8\text{ V to }35\text{ V}$		$\pm 0.3\%$	$\pm 1\%$		$\pm 1\%$	$\pm 2\%$	
Frequency change with temperature	$T_A = \text{MIN to MAX}$		$\pm 3\%$	$\pm 6\%$		$\pm 3\%$	$\pm 6\%$	
Output amplitude at Pin 4	$R_T = 3.6\text{ k}\Omega$, $R_D = 0\text{ }\Omega$, $C_T = 0.1\text{ }\mu\text{F}$, $f = 40\text{ kHz}$	3	3.5		3	3.5		V
Output pulse duration at Pin 4	$R_T = 3.5\text{ k}\Omega$, $R_D = 0\text{ }\Omega$, $C_T = 0.1\text{ }\mu\text{F}$, $f = 40\text{ kHz}$, $T_J = 25^\circ\text{C}$	0.3	0.5	1	0.3	0.6	1	μs
Input threshold voltage at Pin 3		1.2	2	2.8	1.2	2	2.8	V
Input current at Pin 3	$V_{I(\text{Pin}3)} = 3.5\text{ V}$		1.6	2.5		1.6	2.5	mA
Current through Pin 5 due to internal current mirror	Current through Pin 6 = 6 mA	1.7	2	2.2	1.7	2	2.2	mA

NOTE 3: Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPES TL1525A, TL1527A, TL2525A, TL2527A, TL3525A, TL3527A PULSE-WIDTH MODULATION CONTROLLERS

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 20\text{ V}$
(unless otherwise noted)

error amplifier section

PARAMETER	TEST CONDITIONS	TL1525A, TL1527A TL2525A, TL2527A			TL3525A, TL3527A			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
High-level output voltage		3.8	5.6		3.8	5.6		V
Low-level output voltage			0.2	0.5		0.2	0.5	V
Input offset voltage			0.5	5		2	10	mV
Input bias current			1	10		1	10	μA
Input offset current				1			1	μA
Open-loop voltage amplification	$R_L \geq 10\text{ M}$	60	75		60	75		dB
Common-mode rejection ratio	$V_{IC} = 1.5\text{ V to } 5.2\text{ V}$	60	75		60	75		dB
Supply voltage rejection ratio	$V_{CC} = 8\text{ V to } 35\text{ V}$	50	60		50	60		dB
Gain-bandwidth product (see Note 3)	$A_V = 0\text{ dB}, T_J = 25^\circ\text{C}$	1	2		1	2		MHz

comparator section

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input threshold voltage	$R_T = 3.6\text{ k}\Omega$,	Duty cycle = 0%	0.6	0.9		V
	$R_D = 0\text{ }\Omega$,	Duty cycle = MAX		3.3	3.6	
	$C_T = 10\text{ nF}, f = 40\text{ kHz}$					
Input bias current			0.5	1		μA

soft-start section

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Soft-start voltage	V_I at Pin 10 = 2 V		0.4	0.6	V
Soft-start current	V_I at Pin 10 = 0 V	25	50	80	μA
Input current, Shutdown	V_I at Pin 10 = 2.5 V		0.4	1	mA

output section

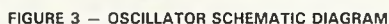
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
High-level output voltage	$I_{OH} = -20\text{ mA}$	18	19		V
	$I_{OH} = -100\text{ mA}$	17	18		
Low-level output voltage	$I_{OL} = 20\text{ mA}$		0.2	0.4	V
	$I_{OL} = 100\text{ mA}$		1	2	
Under-voltage lockout voltage	V_I at Pins 8 and 9 high	6	7	8	V
Oscillator cutoff current (see Note 4)	$V_C = 35\text{ V}, I_O = 100\text{ mA}$			200	μA
Output pulse rise time	$C_L = 1\text{ nF}, T_J = 25^\circ\text{C}$		100	600	ns
Output pulse fall time	$C_L = 1\text{ nF}, T_J = 25^\circ\text{C}$		50	300	ns
Shutdown delay time	V_I at Pin 10 = 3 V, capacitance at pin 8 = 0, $T_J = 25^\circ\text{C}$		0.2	0.5	μs

NOTE 4: Collector cutoff current specifications apply only for the TL1525A, TL2525A, and TL3625A devices.

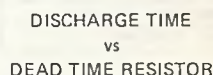
total device

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Minimum duty cycle				0%	
Maximum duty cycle		45%	49%		
Standby current	$V_{CC} = 35\text{ V}$		14	20	mA

2



CHARGING TIME VS TIMING RESISTOR



TYPES TL1525A, TL1527A, TL2525A, TL2527A, TL3525A, TL3527A PULSE-WIDTH MODULATION CONTROLLERS

TYPICAL CHARACTERISTICS

ERROR AMPLIFIER OPEN-LOOP
FREQUENCY RESPONSE

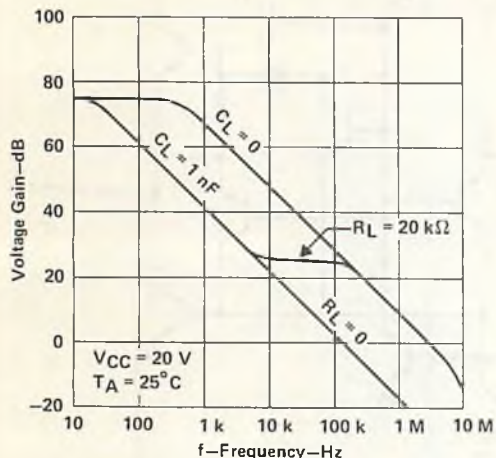


FIGURE 6

TL1525A OUTPUT SATURATION VOLTAGE
VS
OUTPUT CURRENT

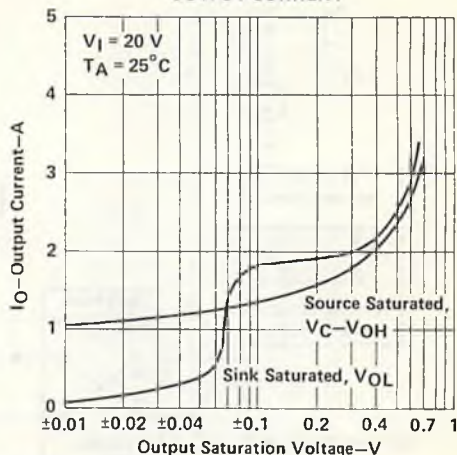


FIGURE 7

2

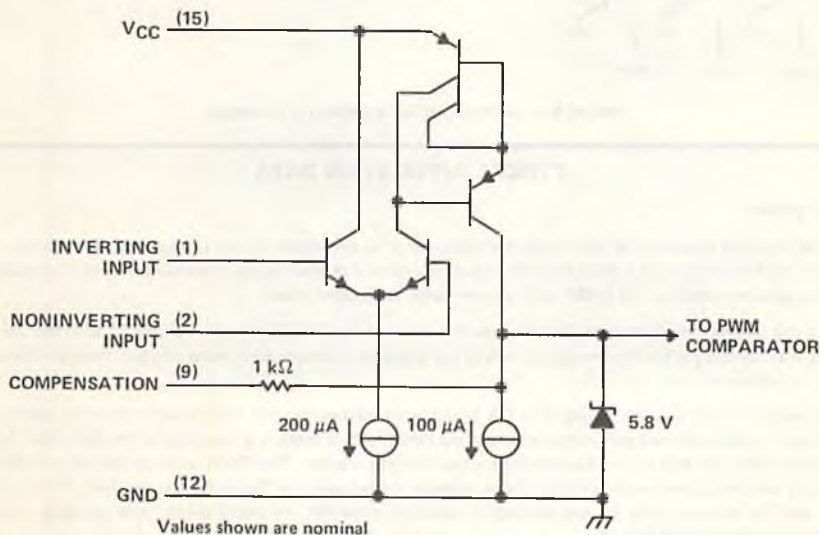


FIGURE 8 — ERROR AMPLIFIER SCHEMATIC DIAGRAM

TYPES TL1525A, TL1527A, TL2525A, TL2527A, TL3525A, TL3527A PULSE-WIDTH MODULATION CONTROLLERS

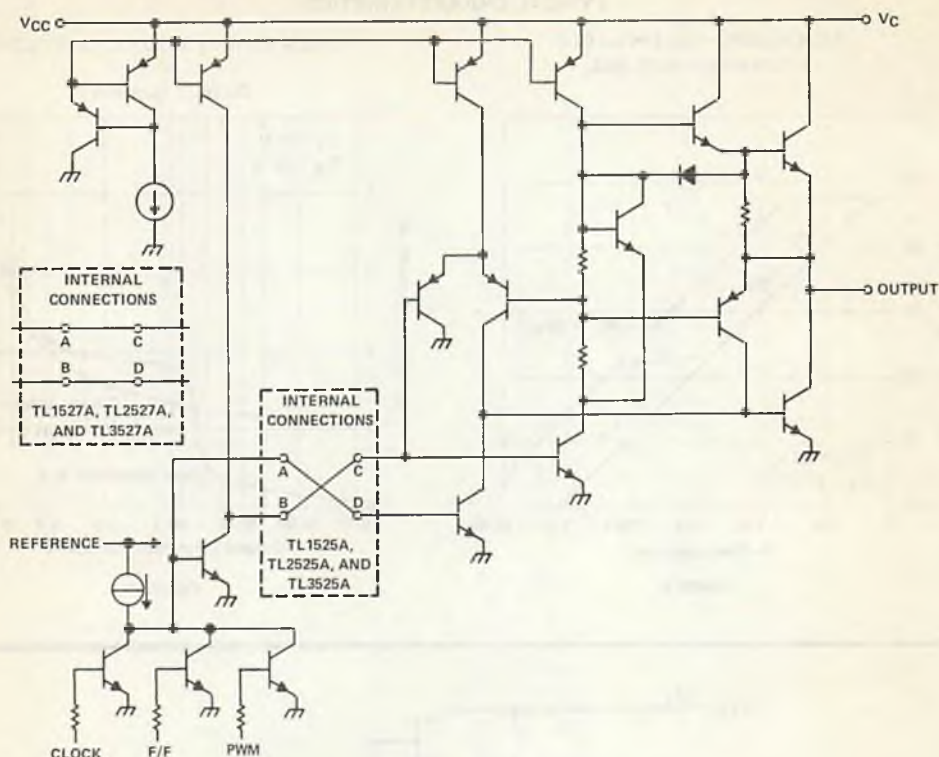


FIGURE 9 — OUTPUT CIRCUIT SCHEMATIC DIAGRAM

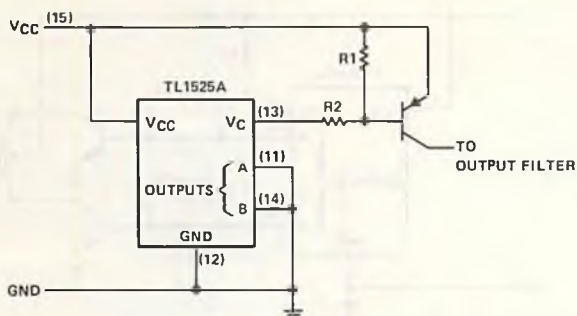
TYPICAL APPLICATION DATA

shutdown options

1. Use an external transistor or open-collector comparator to pull down on the Compensation terminal (Pin 9). This will set the PWM latch and turn off both driver outputs. If the shutdown signal is momentary, pulse-by-pulse protection will be accomplished as the PWM latch is reset with each clock pulse.
2. The same results may be accomplished by pulling down on the Soft-Start terminal (Pin 8) with the only difference being that on this pin shutdown will not affect the amplifier compensation network, but must discharge any soft-start capacitance.
3. Application of a positive-going signal to the Shutdown terminal (Pin 10) will provide the most rapid shutdown of the driver outputs but will not immediately set the PWM latch if there is a capacitor at the Soft-Start terminal. The capacitor will discharge but at a current twice the charging current. The PWM latch can be set on a pulse-by-pulse basis by the shutdown terminal if there is no external capacitance on the Soft-start terminal (Pin 8). Slow turn-on may still be accomplished by connecting an external capacitor, blocking diode, and charging resistor to the Compensation terminal (Pin 9).

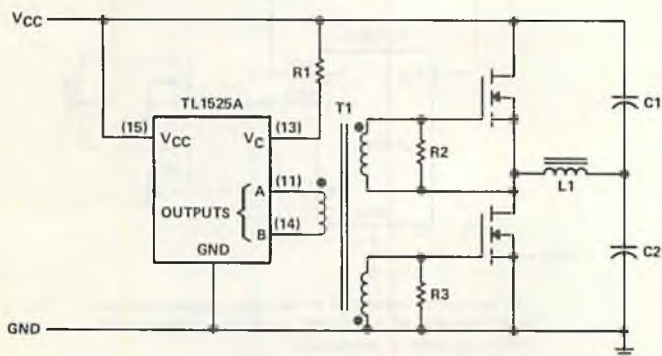
TYPES TL1525A, TL1527A, TL2525A, TL2527A, TL3525A, TL3527A PULSE-WIDTH MODULATION CONTROLLERS

TYPICAL APPLICATION DATA



For single-ended supplies, the driver outputs are grounded. The V_C terminal is switched to ground by the totem-pole source transistors on the alternate oscillator cycles.

FIGURE 10 — SINGLE-ENDED CIRCUIT

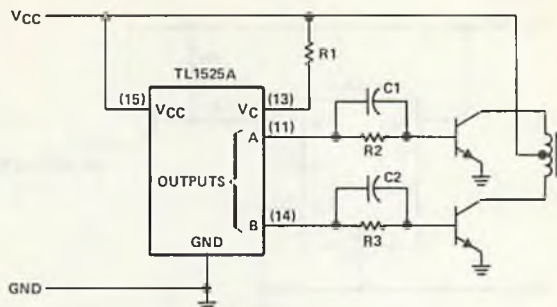


Low-power transformers can be directly driven by the TL1525A. Automatic reset occurs during deadtime when both ends of the primary winding are switched to ground.

FIGURE 11 — TRANSFORMER-COUPLED CIRCUIT

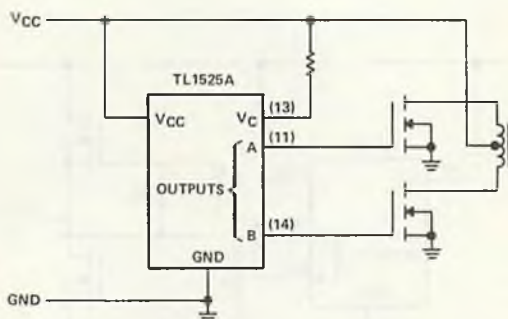
TYPES TL1525A, TL1527A, TL2525A, TL2527A, TL3525A, TL3527A PULSE-WIDTH MODULATION CONTROLLERS

TYPICAL APPLICATION DATA



In conventional push-pull bipolar designs, forward base drive is controlled by $R_1 - R_3$. Rapid turn-off times for the power devices are achieved with speed-up capacitors C_1 and C_2 .

FIGURE 12 — BIPOLAR PUSH-PULL CIRCUIT

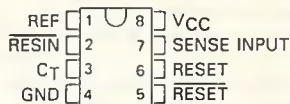


The low source impedance of the output drivers provides rapid charging of power FET input capacitance while minimizing external components.

FIGURE 13 — LOW-IMPEDANCE BIPOLAR-DRIVE
PUSH-PULL CIRCUIT

- Power On Reset Generator
- Automatic Reset Generation After Voltage Drop
- Wide Supply Voltage Range . . . 3 V to 18 V
- Precision Voltage Sensor
- Temperature-Compensated Voltage Reference
- True and Complement Reset Outputs
- Externally Adjustable Pulse Width

P DUAL-IN-LINE PACKAGE
(TOP VIEW)



description

The TL7702 series are monolithic integrated circuit supply voltage supervisors specifically designed for use as reset controllers in microcomputer and microprocessor systems. During power-up the device tests the supply voltage and keeps the reset outputs active as long as the supply voltage has not reached its nominal voltage value. Taking RESIN low has the same effect. To ensure that the microcomputer system has reset, the TL7702 then initiates an internal time delay that delays the return of the reset outputs to their inactive states. Since the time delay for most microcomputers and microprocessors is in the order of several machine cycles, the device internal time delay is determined by an external capacitor connected to the C_T input (pin 3).

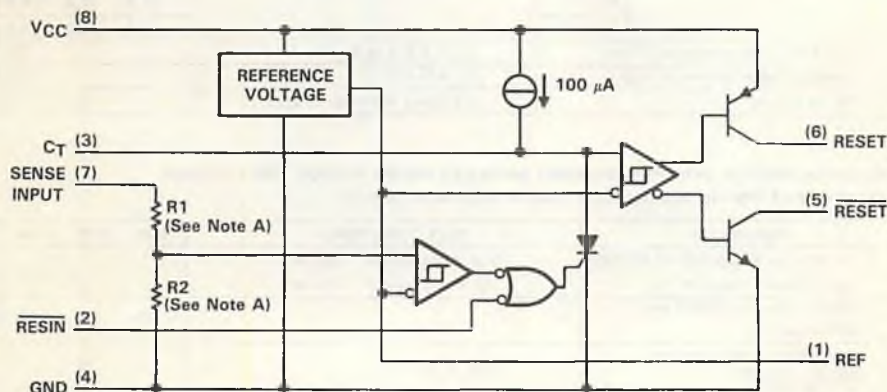
$$t_d = 1.3 \times 10^4 \times C_T$$

Where: C_T is in farads (F)
t_d is in seconds (s)

In addition, when the supply voltage drops below the nominal value, the outputs become active and stay in this state until the supply voltage returns to the nominal value. An external capacitor (typically 0.1 μF) must be connected to the REF output (pin 1) to reduce the influence of fast transients in the supply voltage.

The TL7702 series is characterized for operation from 0°C to 70°C.

functional block diagram



All resistor and current values shown are nominal.

NOTE A: TL7702: R1 = 0 Ω, R2 = open
TL7705: R1 = 9 kΩ, R2 = 10 kΩ
TL7709: R1 = 20.4 kΩ, R2 = 10 kΩ
TL7712: R1 = 36.6 kΩ, R2 = 10 kΩ
TL7715: R1 = 46.8 kΩ, R2 = 10 kΩ

ADVANCE INFORMATION

This document contains information on a new product. Specifications are subject to change without notice.

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TYPES TL7702, TL7705, TL7712, TL7715

SUPPLY VOLTAGE SUPERVISORS

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1)	20 V
Input voltage range at RESIN	-0.3 V to 20 V
Input voltage range at SENSE: TL7702	-0.3 V to 6 V
TL7705, TL7709, TL7712, and TL7715	-0.3 V to 20 V
Operating free-air temperature range	0°C to 70°C
Storage temperature range	-65°C to 150°C

NOTE 1: All voltage values are with respect to the network ground terminal.

recommended operating conditions

	MIN	NOM	MAX	UNIT
Supply voltage	3		18	V
High-level input voltage at RESIN, V_{IH}	2			V
Low-level input voltage at RESIN, V_{IL}			0.7	V
High-level output current at RESET, I_{OH}			-1	mA
Low-level output current at RESET, I_{OL}			16	mA
Operating free-air temperature range, T_A	0		70	°C

electrical characteristics over recommended ranges of supply voltage, input voltage, output current, and free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS [†]	MIN	TYP	MAX	UNIT
V_{OH}	High-level output voltage at RESET	$I_{OH} = -1$ mA	$V_{CC} - 1$			V
V_{OL}	Low-level output voltage at RESET	$I_{OH} = 16$ mA			0.4	V
V_{ref}	Reference voltage			2.5		V
V_S	Sense voltage	TL7702	$V_{CC} = 3.5$ V to 18 V		V_{ref}	V
		TL7705			4.7	
		TL7709			4.75	
		TL7712			7.5	
		TL7715			7.6	
I_{IH}	High-level input current at RESIN	$V_I = 2.4$ V to V_{CC}				20 μ A
I_{IL}	Low-level input current at RESIN	$V_I = 0.4$ V			-100	μ A
I_{CC}	Supply current	All inputs and outputs open		1.8	3	mA

switching characteristics over recommended ranges of supply voltage, input voltage, output current, and free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS [†]	MIN	TYP	MAX	UNIT
t_{wS}	Minimum pulse duration at SENSE input to switch outputs	$V_{IH} = V_S$ typical + 200 mV, $V_{IL} = V_S$ typical - 200 mV			0.5	μ s
t_w	Pulse duration at RESET and RESET outputs		0.65	1.3	2.6	ms
t_{pd}	Propagation delay time from RESIN to RESET	$V_{CC} = 5$ V		9		μ s
t_r	Rise time at RESET and RESET	$V_{CC} = 5$ V, see Note 2			1	μ s
t_f	Fall time at RESET and RESET	$V_{CC} = 5$ V, see Note 2			1	μ s

[†]All characteristics are measured with 0.1- μ F capacitors connected at pins 1 and 2 to ground.

NOTE 2: The rise and fall times are measured with a 4.7-k Ω load resistor at RESET (pin 5) and RESET (pin 6).

PARAMETER MEASUREMENT INFORMATION

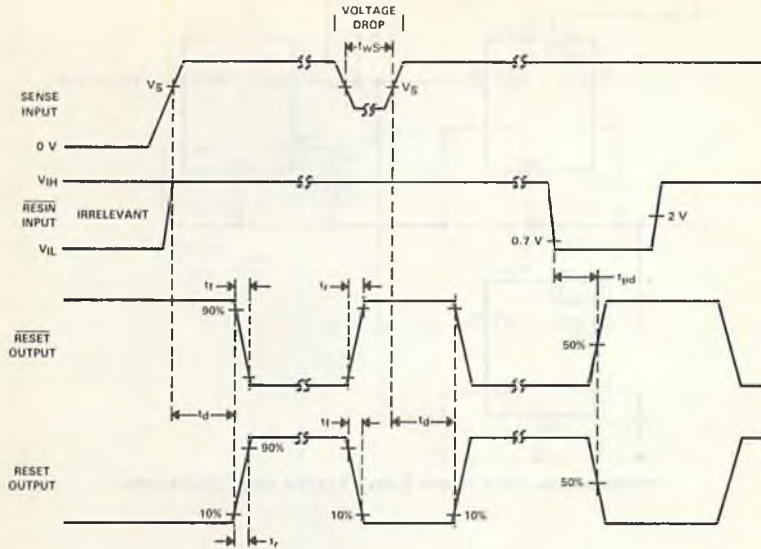


FIGURE 1 — SWITCHING DIAGRAM

2

TYPICAL CHARACTERISTICS

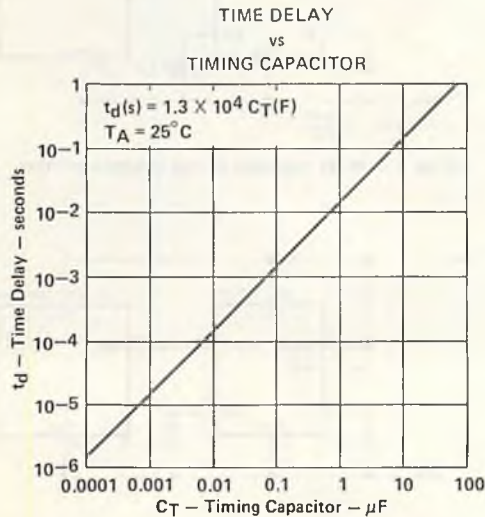


FIGURE 2

TYPES TL7702, TL7705, TL7712, TL7715 SUPPLY VOLTAGE SUPERVISORS

TYPICAL APPLICATION DATA

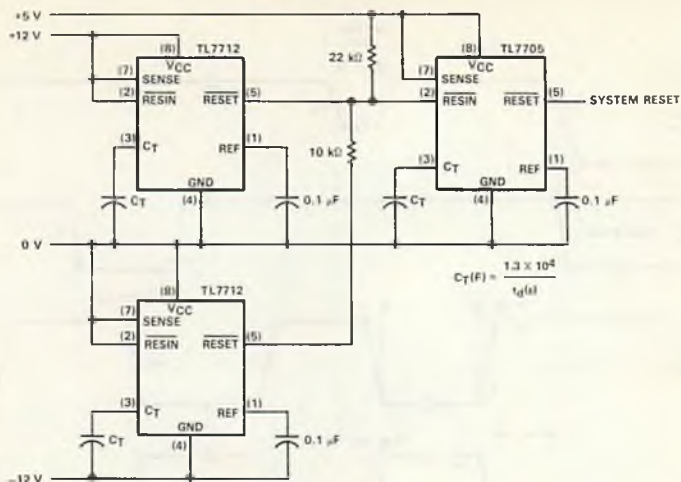


FIGURE 3 — MULTIPLE POWER SUPPLY SYSTEM RESET GENERATION

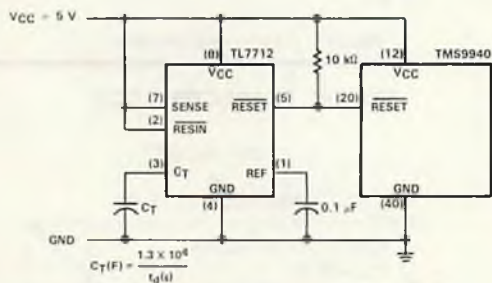


FIGURE 4 — RESET CONTROLLER FOR TMS9940 SYSTEM

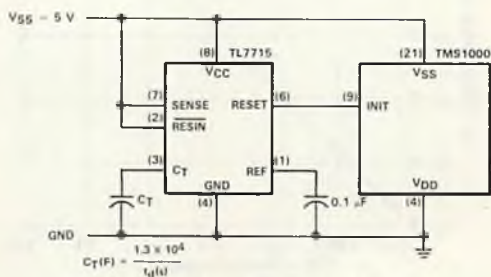


FIGURE 5 — RESET CONTROLLER FOR TMS1000

- 150-mA Load Current without External Power Transistor
- Typically 0.02% Input Regulation and 0.03% Load Regulation (μ A723M)
- Adjustable Current Limiting Capability

- Input Voltages to 40 Volts
- Output Adjustable from 2 to 37 Volts
- Direct Replacement for Fairchild μ A723M and μ A723C

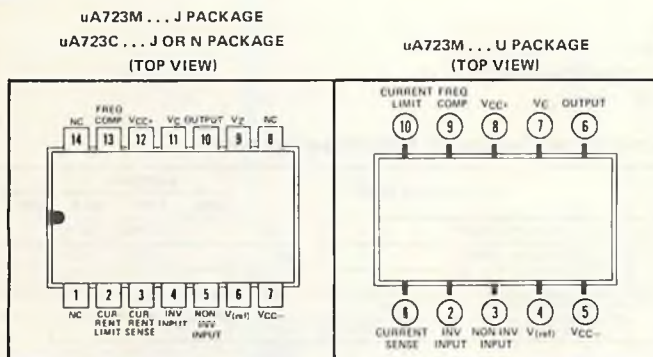
description

The μ A723M and μ A723C are monolithic integrated circuit voltage regulators featuring high ripple rejection, excellent input and load regulation, excellent temperature stability, and low standby current. The circuit consists of a temperature-compensated reference voltage amplifier, an error amplifier, a 150-milliampere output transistor, and an adjustable output current limiter.

The μ A723M and μ A723C are designed for use in positive or negative power supplies as a series, shunt, switching, or floating regulator. For output currents exceeding 150 mA, additional pass elements may be connected as shown in Figures 4 and 5.

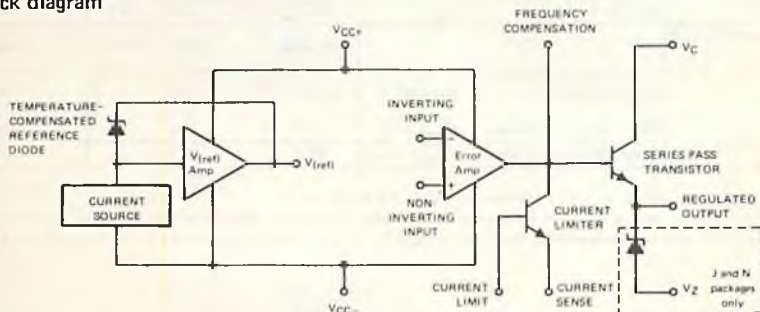
The μ A723M is characterized for operation over the full military temperature range of -55°C to 125°C ; the μ A723C is characterized for operation from 0°C to 70°C .

terminal assignments



NC—No internal connection

functional block diagram



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PRECISION VOLTAGE REGULATORS

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Peak voltage from V _{CC+} to V _{CC-} (<i>t</i> _w ≤ 50 ms)	50 V
Continuous voltage from V _{CC+} to V _{CC-}	40 V
Input-to-output voltage differential	40 V
Differential input voltage to error amplifier	±5 V
Voltage between noninverting input and V _{CC-}	8 V
Current from V _Z	25 mA
Current from V _(ref)	15 mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 1):	
J or N package	1000 mW
U package	675 mW
Operating free-air temperature range: uA723M Circuits	-55°C to 125°C
uA723C Circuits	0°C to 70°C
Storage temperature range	-65°C to 150°C
Lead temperature 1.6 mm (1/16 inch) from case for 60 seconds, J or U package	300°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds, N package	260°C

NOTE 1: Power dissipation = $I(I_{\text{standby}} + I_{\text{ref}}) V_{CC} + (V_C - V_{OL}) I_O$. For operation at elevated temperature, refer to Dissipation Derating Table. In the J package, uA723M chips are alloy-mounted; uA723C chips are glass-mounted.

recommended operating conditions

	MIN	MAX	UNIT
Input voltage, V_I	9.5	40	V
Output voltage, V_O	2	37	V
Input-to-output voltage differential, $V_C - V_O$	3	38	V
Output current, I_O		150	mA

electrical characteristics at specified free-air temperature (see note 2)

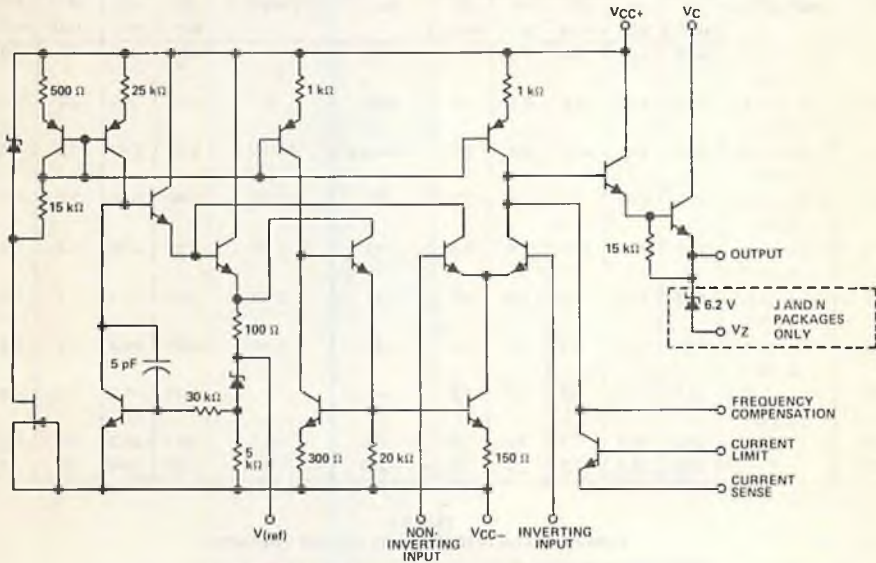
PARAMETER	TEST CONDITIONS†		uA723M			uA723C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Input regulation	$V_I = 12\text{ V to }V_I = 15\text{ V}$	25°C	0.01%	0.1%		0.01%	0.1%		
	$V_I = 12\text{ V to }V_I = 40\text{ V}$	25°C	0.02%	0.2%		0.1%	0.5%		
	$V_I = 12\text{ V to }V_I = 15\text{ V}$	Full range			0.3%			0.3%	
Ripple rejection	$f = 50\text{ Hz to }10\text{ kHz}, C_{(\text{ref})} = 0$	25°C	74			74			dB
	$f = 50\text{ Hz to }10\text{ kHz}, C_{(\text{ref})} = 5\text{ }\mu\text{F}$	25°C	86			86			
Output regulation	$I_O = 1\text{ mA to }I_O = 50\text{ mA}$	25°C	-0.03%	-0.15%		-0.03%	-0.2%		
		Full range		-0.6%			-0.6%		
Reference voltage, $V_{(\text{ref})}$		25°C	6.95	7.15	7.35	6.8	7.15	7.5	V
Standby current	$V_I = 30\text{ V}, I_O = 0$	25°C	2.3	3.5		2.3	4		mA
Temperature coefficient of output voltage		Full range	0.002	0.015		0.003	0.015		%/ $^\circ\text{C}$
Short-circuit output current	$R_{\text{SC}} = 10\text{ }\Omega, V_O = 0$	25°C	65			65			mA
Output noise voltage	$\text{BW} = 100\text{ Hz to }10\text{ kHz}, C_{(\text{ref})} = 0$	25°C	20			20			μV
	$\text{BW} = 100\text{ Hz to }10\text{ kHz}, C_{(\text{ref})} = 5\text{ }\mu\text{F}$	25°C	2.5			2.5			

[†] Full range for $\mu A723M$ is $-55^{\circ}C$ to $125^{\circ}C$ and for $\mu A723C$ is $0^{\circ}C$ to $70^{\circ}C$.

NOTE 2: For all values in this table the device is connected as shown in Figure 1 with the divider resistance as seen by the error amplifier $\leq 10\text{ k}\Omega$. Unless otherwise specified, $V_I = V_{CC1} = V_C = 12\text{ V}$, $V_{CC2} = 0$, $V_O = 5\text{ V}$, $I_O = 1\text{ mA}$, $R_{SC} = 0$, and $C_{(ref)} = 0$.

TYPES $\mu A723M$, $\mu A723C$ PRECISION VOLTAGE REGULATORS

schematic



DISSIPATION DERATING TABLE

POWER	POWER RATING	DERATING FACTOR	ABOVE T_A
J (Alloy-Mounted Chip)	1000 mW	11.0 mW/°C	59°C
J (Glass-Mounted Chip)	1000 mW	8.2 mW/°C	28°C
N	1000 mW	9.2 mW/°C	41°C
U	675 mW	5.4 mW/°C	25°C

TYPES $\mu A723M$, $\mu A723C$ PRECISION VOLTAGE REGULATORS

TYPICAL APPLICATION DATA

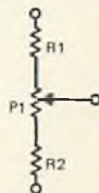
TABLE I
RESISTOR VALUES ($k\Omega$) FOR STANDARD OUTPUT VOLTAGES

OUTPUT VOLTAGE (V)	APPLICABLE FIGURES (SEE NOTE 4)	FIXED OUTPUT $\pm 5\%$		OUTPUT ADJUSTABLE $\pm 10\%$ (SEE NOTE 5)			OUTPUT VOLTAGE (V)	APPLICABLE FIGURES (SEE NOTE 4)	FIXED OUTPUT $\pm 5\%$		OUTPUT ADJUSTABLE $\pm 10\%$ (SEE NOTE 5)		
		R1 ($k\Omega$)	R2 ($k\Omega$)	R1 ($k\Omega$)	P1 ($k\Omega$)	R2 ($k\Omega$)			R1 ($k\Omega$)	R2 ($k\Omega$)	R1 ($k\Omega$)	P1 ($k\Omega$)	R2 ($k\Omega$)
+3.0	1, 5, 6, 9, 11, 12 (4)	4.12	3.01	1.8	0.5	1.2	+100	7	3.57	105	2.2	10	91
+3.6	1, 5, 6, 9, 11, 12 (4)	3.57	3.65	1.5	0.5	1.5	+250	7	3.57	255	2.2	10	240
+5.0	1, 5, 6, 9, 11, 12 (4)	2.15	4.99	0.75	0.5	2.2	-6 (Note 6)	3, (10)	3.57	2.43	1.2	0.5	0.75
+6.0	1, 5, 6, 9, 11, 12 (4)	1.15	6.04	0.5	0.5	2.7	-9	3, 10	3.48	5.36	1.2	0.5	2.0
+9.0	2, 4, (5, 6, 9, 12)	1.87	7.15	0.75	1.0	2.7	-12	3, 10	3.57	8.45	1.2	0.5	3.3
+12	2, 4, (5, 6, 9, 12)	4.87	7.15	2.0	1.0	3.0	-15	3, 10	3.57	11.5	1.2	0.5	4.3
+15	2, 4, (5, 6, 9, 12)	7.87	7.15	3.3	1.0	3.0	-28	3, 10	3.57	24.3	1.2	0.5	10
+28	2, 4, (5, 6, 9, 12)	21.0	7.15	5.6	1.0	2.0	-45	8	3.57	41.2	2.2	10	33
+45	7	3.57	48.7	2.2	10	39	-100	8	3.57	95.3	2.2	10	91
+75	7	3.57	78.7	2.2	10	68	-250	8	3.57	249	2.2	10	240

TABLE II
FORMULAS FOR INTERMEDIATE OUTPUT VOLTAGES

<p>Outputs from +2 to +7 volts [Figures 1, 5, 6, 9, 11, 12, 14]</p> $V_O = V_{(ref)} \times \frac{R_2}{R_1 + R_2}$	<p>Outputs from +4 to +250 volts [Figure 7]</p> $V_O = \frac{V_{(ref)}}{2} \times \frac{R_2 - R_1}{R_1}$ <p>$R_3 = R_4$</p>	<p>Current Limiting</p> $I_{(limit)} \approx \frac{0.65 V}{R_{sc}}$
<p>Outputs from +7 to +37 volts [Figures 2, 4, (5, 6, 9, 11, 12)]</p> $V_O = V_{(ref)} \times \frac{R_1 + R_2}{R_2}$	<p>Outputs from -6 to -250 volts [Figures 3, 8, 10]</p> $V_O = -\frac{V_{(ref)}}{2} \times \frac{R_1 + R_2}{R_1}$ <p>$R_3 = R_4$</p>	<p>Foldback Current Limiting [Figure 6]</p> $I_{(knee)} \approx \frac{V_O R_3 + (R_3 + R_4) 0.65 V}{R_{sc} R_4}$ $I_{OS} \approx \frac{0.65 V}{R_{sc}} \times \frac{R_3 + R_4}{R_4}$

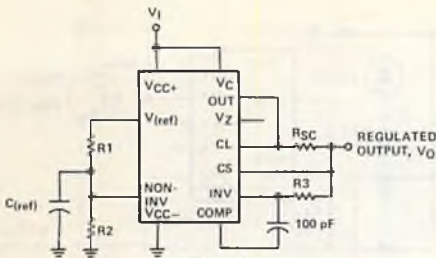
- NOTES: 3. Figures 1 through 12 show the R_1/R_2 divider across either V_O or $V_{(ref)}$. Figure numbers in parentheses may be used if the R_1/R_2 divider is placed across the other voltage ($V_{(ref)}$ or V_O) that it was not placed across in the figures without parentheses.
4. To make the voltage adjustable, the R_1/R_2 divider shown in the figures must be replaced by the divider shown at the right.
5. For negative output voltages less than 9 V, V_{CC+} and V_C must be connected to a positive supply such that the voltage between V_{CC+} and V_{CC-} is greater than 9 V.
6. When 10-lead $\mu A723$ devices are used in applications requiring V_Z , an external 6.2 V regulator diode must be connected in series with the V_O terminal.



ADJUSTABLE OUTPUT CIRCUITS

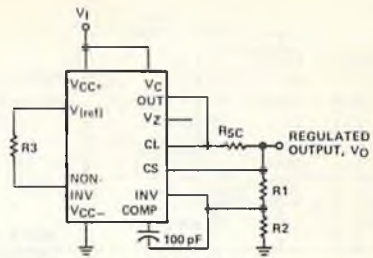
TYPES $\mu A723M$, $\mu A723C$ PRECISION VOLTAGE REGULATORS

TYPICAL APPLICATION DATA



- NOTES: A. $R_3 = \frac{R_1 \cdot R_2}{R_1 + R_2}$ for minimum αV_0 .
B. R_3 may be eliminated for minimum component count. Use direct connection (i.e., $R_3 = 0$).

FIGURE 1—BASIC LOW-VOLTAGE REGULATOR
($V_0 = 2$ TO 7 VOLTS)



- NOTES: A. $R_3 = \frac{R_1 \cdot R_2}{R_1 + R_2}$ for minimum αV_0 .
B. R_3 may be eliminated for minimum component count. Use direct connection (i.e., $R_3 = 0$).

FIGURE 2—BASIC HIGH-VOLTAGE REGULATOR
($V_0 = 7$ TO 37 VOLTS)

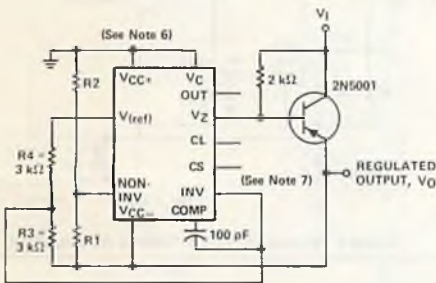


FIGURE 3—NEGATIVE-VOLTAGE REGULATOR

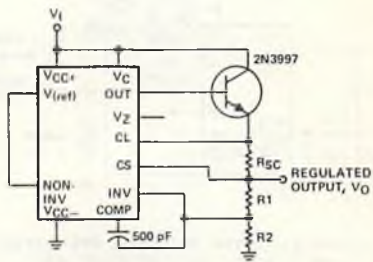


FIGURE 4—POSITIVE-VOLTAGE REGULATOR
(EXTERNAL N-P-N PASS TRANSISTOR)

2

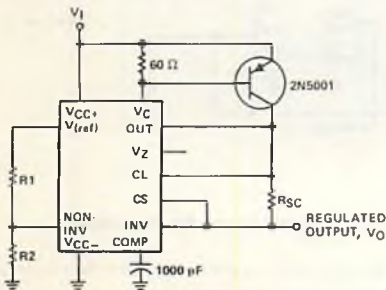


FIGURE 5—POSITIVE-VOLTAGE REGULATOR
(EXTERNAL P-N-P PASS TRANSISTOR)

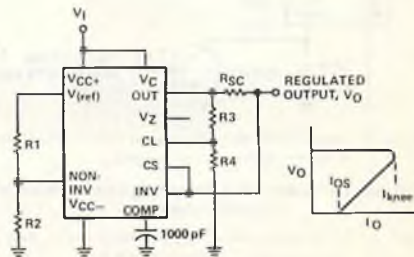


FIGURE 6—FOLDBACK CURRENT LIMITING

TYPES μ A723M, μ A723C

PRECISION VOLTAGE REGULATORS

TYPICAL APPLICATION DATA

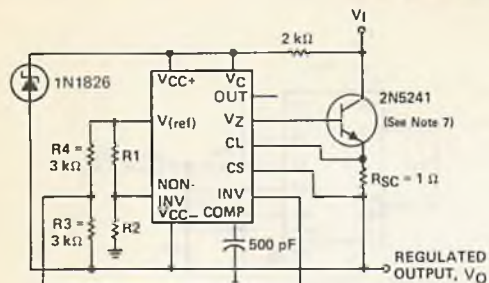


FIGURE 7—POSITIVE FLOATING REGULATOR

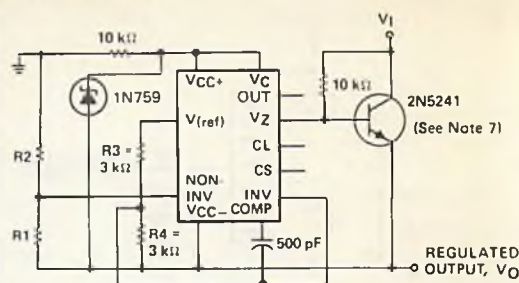


FIGURE 8—NEGATIVE FLOATING REGULATOR

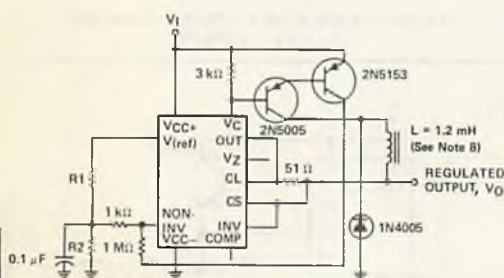


FIGURE 9—POSITIVE SWITCHING REGULATOR

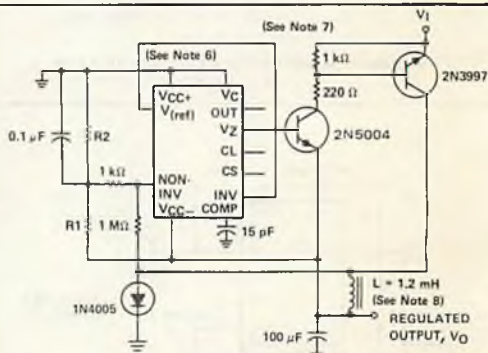
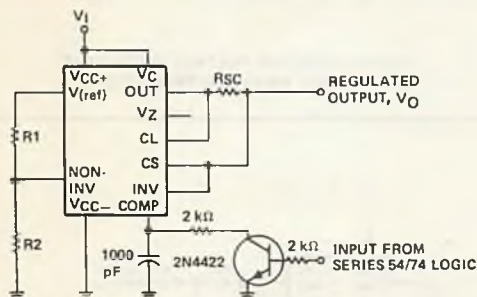


FIGURE 10—NEGATIVE SWITCHING REGULATOR



NOTE A: Current limit transistor may be used for shutdown if current limiting is not required.

FIGURE 11—REMOTE SHUTDOWN REGULATOR WITH CURRENT LIMITING

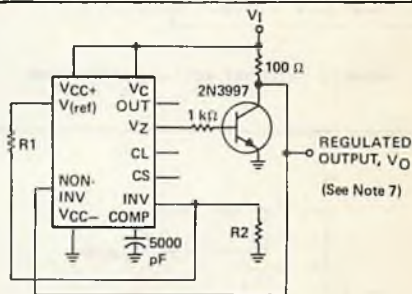


FIGURE 12—SHUNT REGULATOR

- NOTES: 6. For negative output voltages less than 9 V, V_{CC+} and V_C must be connected to a positive supply such that the voltage between V_{CC+} and V_{CC-} is greater than 9 V.
7. When 10-lead μ A723 devices are used in applications requiring V_Z , an external 6.2-V regulator diode must be connected in series with the V_O terminal.
8. L is 40 turns of No. 20 enameled copper wire wound on Ferroxcube P36/22-3B7 potted core, or equivalent, with 0.009-inch air gap.

LINEAR INTEGRATED CIRCUITS

SERIES μ A7800 POSITIVE-VOLTAGE REGULATORS

D2154, MAY 1976—REVISED DECEMBER 1982

- 3-Terminal Regulators
- Output Current up to 1.5 A
- No External Components
- Internal Thermal Overload Protection
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Direct replacements for Fairchild μ A7800 Series

NOMINAL OUTPUT VOLTAGE	REGULATOR
5 V	μ A7805C
6 V	μ A7806C
8 V	μ A7808C
8.5 V	μ A7885C
10 V	μ A7810C
12 V	μ A7812C
15 V	μ A7815C
18 V	μ A7818C
24 V	μ A7824C

description

This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 amperes of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also as the power-pass element in precision regulators.

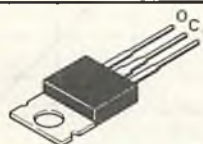
KC PACKAGE

(TOP VIEW)



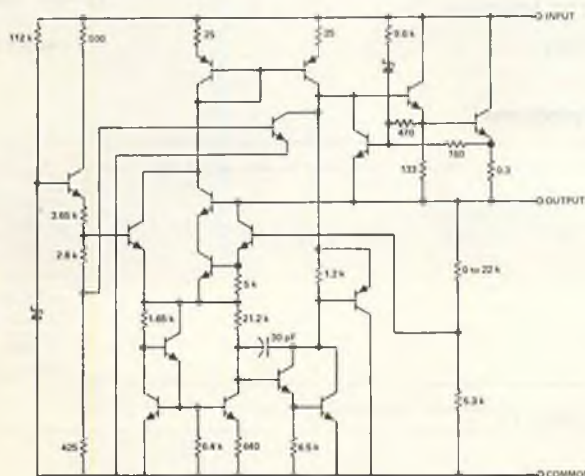
THE COMMON TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



2

schematic



Resistor values shown are nominal and in ohms.

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2-159

SERIES μ A7800

POSITIVE-VOLTAGE REGULATORS

absolute maximum ratings over operating temperature range (unless otherwise noted)

	μ A78__C	UNIT
Input voltage	μ A7824C	40
	All others	35
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2	W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	15	W
Operating free-air, case, or virtual junction temperature range	0 to 150	°C
Storage temperature range	-65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260	°C

Note 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Curves, Figure 1 and Figure 2.

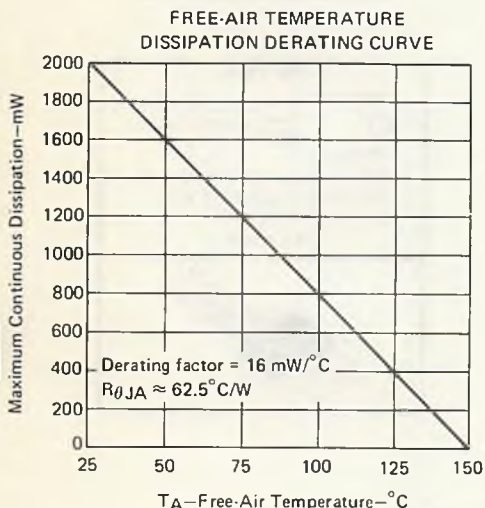


FIGURE 1

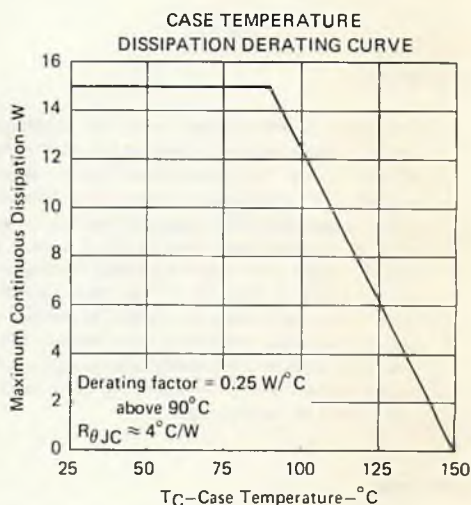


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	μ A7805C	7	25	V
	μ A7806C	8	25	
	μ A7808C	10.5	25	
	μ A7885C	10.5	25	
	μ A7810C	12.5	28	
	μ A7812C	14.5	30	
	μ A7815C	17.5	30	
	μ A7818C	21	33	
	μ A7824C	27	38	
Output current, I_O			1.5	A
Operating virtual junction temperature, T_J		0	125	°C

TYPES μ A7805C, μ A7806C POSITIVE-VOLTAGE REGULATORS

μ A7805C electrical characteristics at specified virtual junction temperature,
 $V_I = 10$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A7805C			UNIT
			MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 1 A, $V_I = 7$ V to 20 V, $P \leq 15$ W	25°C	4.8	5	5.2	V
		0°C to 125°C	4.75		5.25	
Input regulation	$V_I = 7$ V to 25 V	25°C		3	100	mV
	$V_I = 8$ V to 12 V			1	50	
Ripple rejection	$V_I = 8$ V to 18 V, $f = 120$ Hz	0°C to 125°C	62	78		dB
Output regulation	$I_O = 5$ mA to 1.5 A	25°C		15	100	mV
	$I_O = 250$ mA to 750 mA			5	50	
Output resistance	$f = 1$ kHz	0°C to 125°C		0.017		Ω
Temperature coefficient of output voltage	$I_O = 5$ mA	0°C to 125°C		-1.1		mV/°C
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C		40		μ V
Dropout voltage	$I_O = 1$ A	25°C		2.0		V
Bias current		25°C		4.2	8	mA
Bias current change	$V_I = 7$ V to 25 V	0°C to 125°C			1.3	mA
	$I_O = 5$ mA to 1 A				0.5	
Short-circuit output current		25°C		750		mA
Peak output current		25°C		2.2		A

μ A7806C electrical characteristics at specified virtual junction temperature,
 $V_I = 11$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A7806C			UNIT
			MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 1 A, $V_I = 8$ V to 21 V, $P \leq 15$ W	25°C	5.75	6	6.25	V
		0°C to 125°C	5.7		6.3	
Input regulation	$V_I = 8$ V to 25 V	25°C		5	120	mV
	$V_I = 9$ V to 13 V			1.5	60	
Ripple rejection	$V_I = 9$ V to 19 V, $f = 120$ Hz	0°C to 125°C	59	75		dB
Output regulation	$I_O = 5$ mA to 1.5 A	25°C		14	120	mV
	$I_O = 250$ mA to 750 mA			4	60	
Output resistance	$f = 1$ kHz	0°C to 125°C		0.019		Ω
Temperature coefficient of output voltage	$I_O = 5$ mA	0°C to 125°C		-0.8		mV/°C
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C		45		μ V
Dropout voltage	$I_O = 1$ A	25°C		2.0		V
Bias current		25°C		4.3	8	mA
Bias current change	$V_I = 8$ V to 25 V	0°C to 125°C			1.3	mA
	$I_O = 5$ mA to 1 A				0.5	
Short-circuit output current		25°C		550		mA
Peak output current		25°C		2.2		A

† All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_W \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPES μ A7808C, μ A7885C

POSITIVE-VOLTAGE REGULATORS

μ A7808C electrical characteristics at specified virtual junction temperature,
 $V_I = 14$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	μ A7808C			UNIT
		MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 1 A, $V_I = 10.5$ V to 23 V, $P \leq 15$ W	25°C	7.7	8	V
	0°C to 125°C	7.6		8.4	
Input regulation	$V_I = 10.5$ V to 25 V	25°C	6	160	mV
	$V_I = 11$ V to 17 V		2	80	
Ripple rejection	$V_I = 11.5$ V to 21.5 V, $f = 120$ Hz	0°C to 125°C	56	72	dB
Output regulation	$I_O = 5$ mA to 1.5 A	25°C	12	160	mV
	$I_O = 250$ mA to 750 mA		4	80	
Output resistance	$f = 1$ kHz	0°C to 125°C	0.016		Ω
Temperature coefficient of output voltage	$I_O = 5$ mA	0°C to 125°C	-0.8		mV/°C
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C	52		μ V
Dropout voltage	$I_O = 1$ A	25°C	2.0		V
Bias current		25°C	4.3	8	mA
Bias current change	$V_I = 10.5$ V to 25 V	0°C to 125°C		1	mA
	$I_O = 5$ mA to 1 A			0.5	
Short-circuit output current		25°C	450		mA
Peak output current		25°C	2.2		A

μ A7885C electrical characteristics at specified virtual junction temperature,
 $V_I = 15$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	μ A7885C			UNIT
		MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 1 A, $V_I = 11$ V to 23.5 V, $P \leq 15$ W	25°C	8.15	8.5	V
	0°C to 125°C	8.1		8.9	
Input regulation	$V_I = 10.5$ V to 25 V	25°C	6	170	mV
	$V_I = 11$ V to 17 V		2	85	
Ripple rejection	$V_I = 11.5$ V to 21.5 V, $f = 120$ Hz	0°C to 125°C	54	70	dB
Output regulation	$I_O = 5$ mA to 1.5 A	25°C	12	170	mV
	$I_O = 250$ mA to 750 mA		4	85	
Output resistance	$f = 1$ kHz	0°C to 125°C	0.016		Ω
Temperature coefficient of output voltage	$I_O = 5$ mA	0°C to 125°C	-0.8		mV/°C
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C	55		μ V
Dropout voltage	$I_O = 1$ A	25°C	2.0		V
Bias current		25°C	4.3	8	mA
Bias current change	$V_I = 10.5$ V to 25 V	0°C to 125°C		1	mA
	$I_O = 5$ mA to 1 A			0.5	
Short-circuit output current		25°C	450		mA
Peak output current		25°C	2.2		A

†All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPES μ A7810C, μ A7812C

POSITIVE-VOLTAGE REGULATORS

μ A7810C electrical characteristics at specified virtual junction temperature,
 $V_I = 17$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μA7810C			UNIT
			MIN	TYP	MAX	
Output voltage	$I_O = 5\text{ mA to }1\text{ A}, \quad V_I = 12.5\text{ V to }25\text{ V}, \quad P \leq 15\text{ W}$	25°C	9.6	10	10.4	V
		0°C to 125°C	9.5	10	10.5	
Input regulation	$V_I = 12.5\text{ V to }28\text{ V}$	25°C		7	200	mV
	$V_I = 14\text{ V to }20\text{ V}$			2	100	
Ripple rejection	$V_I = 13\text{ V to }23\text{ V}, \quad f = 120\text{ Hz}$	0°C to 125°C	55	71		dB
Output regulation	$I_O = 5\text{ mA to }1.5\text{ A}$	25°C		12	200	mV
	$I_O = 250\text{ mA to }750\text{ mA}$			4	100	
Output resistance	$f = 1\text{ kHz}$	0°C to 125°C	0.018			Ω
Temperature coefficient of output voltage	$I_O = 5\text{ mA}$	0°C to 125°C	-1.0			mV/°C
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C	70			μV
Dropout voltage	$I_O = 1\text{ A}$	25°C	2.0			V
Bias current		25°C	4.3 8			mA
Bias current change	$V_I = 12.5\text{ V to }28\text{ V}$	0°C to 125°C				mA
	$I_O = 5\text{ mA to }1\text{ A}$		1 0.5			
Short-circuit output current		25°C	400			mA
Peak output current		25°C	2.2			A

μ A7812C electrical characteristics at specified virtual junction temperature,
 $V_I = 19$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μA7812C			UNIT
			MIN	TYP	MAX	
Output voltage	$I_O = 5\text{ mA to }1\text{ A}, \quad V_I = 14.5\text{ V to }27\text{ V}, \quad P \leq 15\text{ W}$	25°C	11.5	12	12.5	V
		0°C to 125°C	11.4		12.6	
Input regulation	$V_I = 14.5\text{ V to }30\text{ V}$	25°C		10	240	mV
	$V_I = 16\text{ V to }22\text{ V}$			3	120	
Ripple rejection	$V_I = 15\text{ V to }25\text{ V}, \quad f = 120\text{ Hz}$	0°C to 125°C	55	71		dB
Output regulation	$I_O = 5\text{ mA to }1.5\text{ A}$	25°C		12	240	mV
	$I_O = 250\text{ mA to }750\text{ mA}$			4	120	
Output resistance	$f = 1\text{ kHz}$	0°C to 125°C		0.018		Ω
Temperature coefficient of output voltage	$I_O = 5\text{ mA}$	0°C to 125°C		-1.0		mV/°C
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C		75		μV
Dropout voltage	$I_O = 1\text{ A}$	25°C		2.0		V
Bias current		25°C		4.3	8	mA
Bias current change	$V_I = 14.5\text{ V to }30\text{ V}$	0°C to 125°C			1	mA
	$I_O = 5\text{ mA to }1\text{ A}$				0.5	
Short-circuit output current		25°C		350		mA
Peak output current		25°C		2.2		A

† All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPES μ A7815C, μ A7818C

POSITIVE-VOLTAGE REGULATORS

μ A7815C electrical characteristics at specified virtual junction temperature,
 $V_I = 23$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μA7815C			UNIT	
			MIN	TYP	MAX		
Output voltage	$I_O = 5 \text{ mA to } 1 \text{ A,}$ $P \leq 15 \text{ W}$	$V_I = 17.5 \text{ V to } 30 \text{ V,}$	25°C	14.4	15	15.6	V
			0°C to 125°C	14.25		15.75	
Input regulation	$V_I = 17.5 \text{ V to } 30 \text{ V}$	25°C		11	300	mV	
	$V_I = 20 \text{ V to } 26 \text{ V}$			3	150		
Ripple rejection	$V_I = 18.5 \text{ V to } 28.5 \text{ V,}$	$f = 120 \text{ Hz}$	0°C to 125°C	54	70	dB	
Output regulation	$I_O = 5 \text{ mA to } 1.5 \text{ A}$	25°C		12	300	mV	
	$I_O = 250 \text{ mA to } 750 \text{ mA}$			4	150		
Output resistance	$f = 1 \text{ kHz}$	0°C to 125°C		0.019		Ω	
Temperature coefficient of output voltage	$I_O = 5 \text{ mA}$	0°C to 125°C		-1.0		mV/°C	
Output noise voltage	$f = 10 \text{ Hz to } 100 \text{ kHz}$	25°C		90		μV	
Dropout voltage	$I_O = 1 \text{ A}$	25°C		2.0		V	
Bias current		25°C		4.4	8	mA	
Bias current change	$V_I = 17.5 \text{ V to } 30 \text{ V}$	0°C to 125°C			1	mA	
	$I_O = 5 \text{ mA to } 1 \text{ A}$				0.5		
Short-circuit output current		25°C		230		mA	
Peak output current		25°C		2.1		A	

μ A7818C electrical characteristics at specified virtual junction temperature,
 $V_I = 27$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μA7818C			UNIT
			MIN	TYP	MAX	
Output voltage	$I_O = 5\text{ mA to }1\text{ A},$ $P \leq 15\text{ W}$	$V_I = 21\text{ V to }33\text{ V},$ 25°C	17.3	18	18.7	V
		0°C to 125°C	17.1		18.9	
Input regulation	$V_I = 21\text{ V to }33\text{ V}$	25°C		15	360	mV
	$V_I = 24\text{ V to }30\text{ V}$			5	180	
Ripple rejection	$V_I = 22\text{ V to }32\text{ V},$ $f = 120\text{ Hz}$	0°C to 125°C	53	69		dB
Output regulation	$I_O = 5\text{ mA to }1.5\text{ A}$	25°C		12	360	mV
	$I_O = 250\text{ mA to }750\text{ mA}$			4	180	
Output resistance	$f = 1\text{ kHz}$	0°C to 125°C		0.022		Ω
Temperature coefficient of output voltage	$I_O = 5\text{ mA}$	0°C to 125°C		-1.0		mV/°C
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C		110		μV
Dropout voltage	$I_O = 1\text{ A}$	25°C		2.0		V
Bias current		25°C		4.5	8	mA
Bias current change	$V_I = 21\text{ V to }33\text{ V}$	0°C to 125°C			1	mA
	$I_O = 5\text{ mA to }1\text{ A}$				0.5	
Short-circuit output current		25°C		200		mA
Peak output current		25°C		2.1		A

[†] All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_W \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPES μ A7822C, μ A7824C POSITIVE-VOLTAGE REGULATORS

μ A7824C electrical characteristics at specified virtual junction temperature,
 $V_I = 33$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	μ A7824C			UNIT
		MIN	TYP	MAX	
Output voltage	25°C	23	24	25	V
	$I_O = 5$ mA to 1 A, $V_I = 27$ V to 38 V, $P \leq 15$ W 0°C to 125°C	22.8		25.2	
Input regulation	$V_I = 27$ V to 38 V		18	480	mV
	$V_I = 30$ V to 36 V		6	240	
Ripple rejection	$V_I = 28$ V to 38 V, $f = 120$ Hz 0°C to 125°C	50	66		dB
Output regulation	$I_O = 5$ mA to 1.5 A		12	480	mV
	$I_O = 250$ mA to 750 mA 0°C to 125°C		4	240	
Output resistance	$f = 1$ kHz 0°C to 125°C		0.028		Ω
Temperature coefficient of output voltage	$I_O = 5$ mA 0°C to 125°C		-1.5		mV/ $^\circ\text{C}$
Output noise voltage	$f = 10$ Hz to 100 kHz 25°C		170		μV
Dropout voltage	$I_O = 1$ A 25°C		2.0		V
Bias current	25°C		4.6	8	mA
Bias current change	$V_I = 27$ V to 38 V			1	mA
	$I_O = 5$ mA to 1 A 0°C to 125°C			0.5	
Short-circuit output current	25°C		150		mA
Peak output current	25°C		2.1		A

† All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF . All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_W \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

1. Name of subject: [illegible]
2. Date of birth: [illegible]
3. Place of birth: [illegible]
4. Sex: [illegible]
5. Race: [illegible]
6. Height: [illegible]
7. Weight: [illegible]
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9. Hair: [illegible]
10. Complexion: [illegible]
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12. Previous addresses: [illegible]
13. Education: [illegible]
14. Occupation: [illegible]
15. Social Security Number: [illegible]
16. Other identifying numbers: [illegible]
17. Date of last contact: [illegible]
18. Name of informant: [illegible]
19. Date of information: [illegible]
20. Source of information: [illegible]
21. Nature of information: [illegible]
22. Action taken: [illegible]
23. Date of action: [illegible]
24. Name of official: [illegible]
25. Title of official: [illegible]
26. Date of report: [illegible]
27. Name of reporter: [illegible]
28. Title of reporter: [illegible]
29. Date of transcription: [illegible]
30. Name of transcriber: [illegible]

LINEAR INTEGRATED CIRCUITS

SERIES μ A78L00 POSITIVE-VOLTAGE REGULATORS

D2203, JANUARY 1976—REVISED APRIL 1977

- 3-Terminal Regulators
- Output Current up to 100 mA
- No External Components
- Internal Thermal Overload Protection
- Unusually High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Direct Replacement for Fairchild μ A78L00 Series

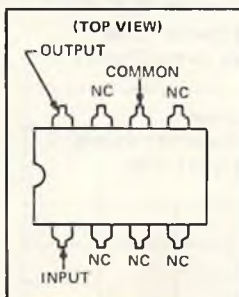
NOMINAL OUTPUT VOLTAGE	5% OUTPUT VOLTAGE TOLERANCE	10% OUTPUT VOLTAGE TOLERANCE
2.6 V	μ A78L02AC	μ A78L02C
5 V	μ A78L05AC	μ A78L05C
6.2 V	μ A78L06AC	μ A78L06C
8 V	μ A78L08AC	μ A78L08C
9 V	μ A78L09AC	μ A78L09C
10 V	μ A78L10AC	μ A78L10C
12 V	μ A78L12AC	μ A78L12C
15 V	μ A78L15AC	μ A78L15C

description

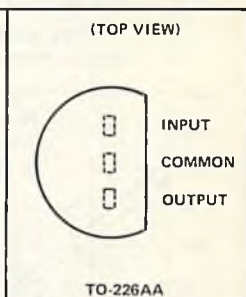
This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. In addition, they can be used with power-pass elements to make high-current voltage regulators. One of these regulators can deliver up to 100 mA of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. When used as a replacement for a Zener-diode-resistor combination, an effective improvement in output impedance of typically two orders of magnitude can be obtained together with lower bias current.

schematic

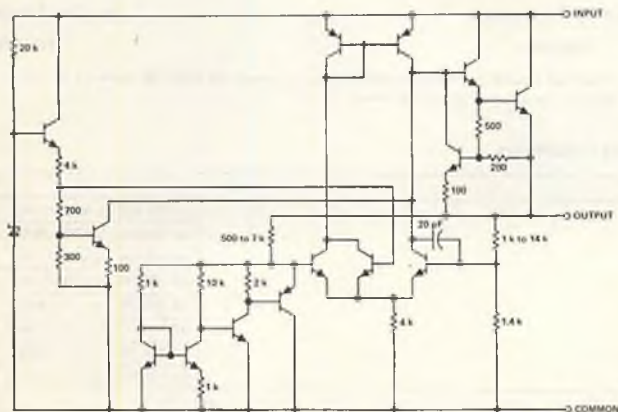
JG
DUAL-IN-LINE PACKAGE



LP
SILECT PACKAGE



NC — No internal connection



Resistor values shown are nominal and in ohms.

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INCORPORATED
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SERIES μ A78L00

POSITIVE-VOLTAGE REGULATORS

absolute maximum ratings over operating temperature range (unless otherwise noted)

		μ A78L02AC, μ A78L02C THRU μ A78L10AC, μ A78L10C	μ A78L12AC, μ A78L12C μ A78L15AC, μ A78L15C	UNIT
Input voltage		30	35	V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	JG package	825	825	mW
	LP package	775	775	
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)		1600	1600	mW
Operating free-air, case, or virtual junction temperature range		0 to 150	0 to 150	°C
Storage temperature range		-65 to 150	-65 to 150	°C
Lead temperature 1/16 inch from case for 10 seconds		260	260	°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Curves, Figure 1 and Figure 2.

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

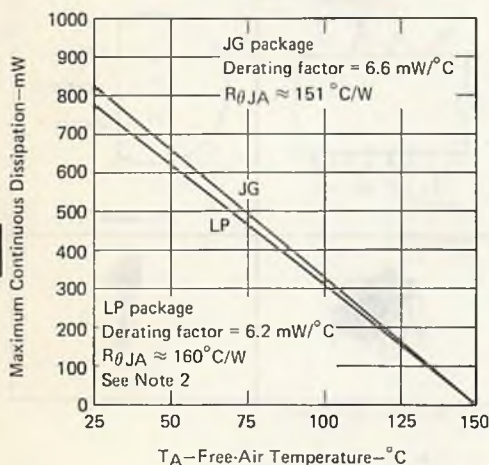


FIGURE 1

CASE TEMPERATURE
DISSIPATION DERATING CURVE

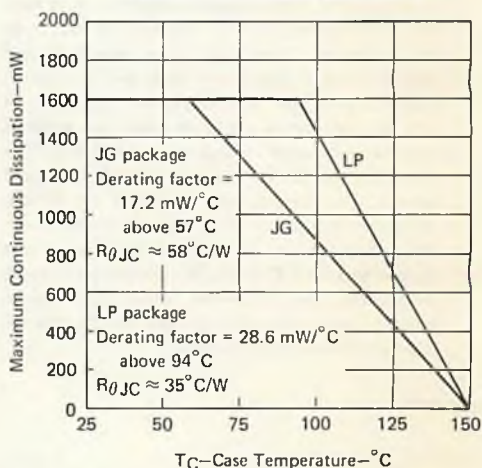


FIGURE 2

NOTE 2: This curve for the LP package is based on thermal resistance, $R_{\theta JA}$, measured in still air with the device mounted in an Augat socket. The bottom of the package was 3/8 inch above the socket.

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	μ A78L02C, μ A78L02AC	4.75	20	V
	μ A78L05C, μ A78L05AC	7	20	
	μ A78L06C, μ A78L06AC	8.5	20	
	μ A78L08C, μ A78L08AC	10.5	23	
	μ A78L09C, μ A78L09AC	11.5	24	
	μ A78L10C, μ A78L10AC	12.5	25	
	μ A78L12C, μ A78L12AC	14.5	27	
	μ A78L15C, μ A78L15AC	17.5	30	
Output current, I_O			100	mA
Operating virtual junction temperature, T_J		0	125	°C

SERIES μ A78L00

POSITIVE-VOLTAGE REGULATORS

μ A78L02AC, μ A78L02C electrical characteristics at specified virtual junction temperature,
 $V_I = 9$ V, $I_O = 40$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A78L02AC			μ A78L02C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$V_I = 4.75$ V to 20 V, $I_O = 1$ mA to 40 mA	25°C	2.5	2.6	2.7	2.4	2.6	2.8	V
	$I_O = 1$ mA to 70 mA	0°C to 125°C	2.45	2.75		2.35		2.85	
			2.45	2.75		2.35		2.85	
Input regulation	$V_I = 4.75$ V to 20 V	25°C	20	100		20	125		mV
	$V_I = 5$ V to 20 V		16	75		16	100		
Ripple rejection	$V_I = 6$ V to 16 V, $f = 120$ Hz	25°C	43	51		42	51		dB
Output regulation	$I_O = 1$ mA to 100 mA	25°C	12	50		12	50		mV
	$I_O = 1$ mA to 40 mA		6	25		6	25		
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C	30			30			μ V
Dropout voltage		25°C	1.7			1.7			V
		25°C	3.6	6		3.6	6		mA
Bias current		125°C		5.5			5.5		
Bias current change	$V_I = 5$ V to 20 V	0°C to 125°C		2.5			2.5		mA
	$I_O = 1$ mA to 40 mA			0.1			0.2		

μ A78L05AC, μ A78L05C electrical characteristics at specified virtual junction temperature,
 $V_I = 10$ V, $I_O = 40$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A78L05AC			μ A78L05C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$V_I = 7$ V to 20 V, $I_O = 1$ mA to 40 mA	25°C	4.8	5	5.2	4.6	5	5.4	V
	$I_O = 1$ mA to 70 mA	0°C to 125°C	4.75	5.25		4.5		5.5	
			4.75	5.25		4.5		5.5	
Input regulation	$V_I = 7$ V to 20 V	25°C	32	150		32	200		mV
	$V_I = 8$ V to 20 V		26	100		26	150		
Ripple rejection	$V_I = 8$ V to 18 V, $f = 120$ Hz	25°C	41	49		40	49		dB
Output regulation	$I_O = 1$ mA to 100 mA	25°C	15	60		15	60		mV
	$I_O = 1$ mA to 40 mA		8	30		8	30		
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C	42			42			μ V
Dropout voltage		25°C	1.7			1.7			V
		25°C	3.8	6		3.8	6		mA
Bias current		125°C		5.5			5.5		
Bias current change	$V_I = 8$ V to 20 V	0°C to 125°C		1.5			1.5		mA
	$I_O = 1$ mA to 40 mA			0.1			0.2		

† All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_W \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

SERIES μ A78L00

POSITIVE-VOLTAGE REGULATORS

μ A78L06AC, μ A78L06C electrical characteristics at specified virtual junction temperature,
 $V_I = 12$ V, $I_O = 40$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	μ A78L06AC			μ A78L06C			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	25°C	5.95	6.2	6.45	5.7	6.2	6.7	V
	$V_I = 8.5$ V to 20 V, $I_O = 1$ mA to 40 mA	5.9		6.5	5.6		6.8	
	$I_O = 1$ mA to 70 mA	5.9		6.5	5.6		6.8	
Input regulation	$V_I = 8.5$ V to 20 V		35	175		35	200	mV
	$V_I = 9$ V to 20 V		29	125		29	150	
Ripple rejection	$V_I = 10$ V to 20 V, $f = 120$ Hz	40	48		39	48		dB
Output regulation	$I_O = 1$ mA to 100 mA		16	80		16	80	mV
	$I_O = 1$ mA to 40 mA		9	40		9	40	
Output noise voltage	$f = 10$ Hz to 100 kHz		46			46		μ V
Dropout voltage			1.7			1.7		V
Bias current	25°C		3.9	6		3.9	6	mA
	125°C			5.5			5.5	
Bias current change	$V_I = 9$ V to 20 V			1.5			1.5	mA
	$I_O = 1$ mA to 40 mA			0.1			0.2	

μ A78L08AC, μ A78L08C electrical characteristics at specified virtual junction temperature,
 $V_I = 14$ V, $I_O = 40$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	μ A78L08AC			μ A78L08C			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	25°C	7.7	8	8.3	7.36	8	8.64	V
	$V_I = 10.5$ V to 23 V, $I_O = 1$ mA to 40 mA	7.6		8.4	7.2		8.8	
	$I_O = 1$ mA to 70 mA	7.6		8.4	7.2		8.8	
Input regulation	$V_I = 10.5$ V to 23 V		42	175		42	200	mV
	$V_I = 11$ V to 23 V		36	125		36	150	
Ripple rejection	$V_I = 13$ V to 23 V, $f = 120$ Hz	37	46		36	46		dB
Output regulation	$I_O = 1$ mA to 100 mA		18	80		18	80	mV
	$I_O = 1$ mA to 40 mA		10	40		10	40	
Output noise voltage	$f = 10$ Hz to 100 kHz		54			54		μ V
Dropout voltage			1.7			1.7		V
Bias current	25°C		4	6		4	6	mA
	125°C			5.5			5.5	
Bias current change	$V_I = 11$ V to 23 V			1.5			1.5	mA
	$I_O = 1$ mA to 40 mA			0.1			0.2	

† All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_W \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

SERIES μ A78L00

POSITIVE-VOLTAGE REGULATORS

μ A78L09AC, μ A78L09C electrical characteristics at specified virtual junction temperature,
 $V_I = 16$ V, $I_O = 40$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A78L09AC			μ A78L09C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$V_I = 12$ V to 24 V, $I_O = 1$ mA to 40 mA	25°C	8.6	9	9.4	8.3	9	9.7	V
	$I_O = 1$ mA to 70 mA	0°C to 125°C	8.55		9.45	8.1		9.9	
			8.55		9.45	8.1		9.9	
Input regulation	$V_I = 12$ V to 24 V	25°C		45	175		45	225	mV
	$V_I = 13$ V to 24 V			40	125		40	175	
Ripple rejection	$V_I = 13$ V to 24 V, $f = 120$ Hz	25°C	37	45		36	45		dB
Output regulation	$I_O = 1$ mA to 100 mA	25°C		19	90		19	90	mV
	$I_O = 1$ mA to 40 mA			11	40		11	40	
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C		58			58		μ V
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		4.1	6		4.1	6	mA
		125°C			5.5			5.5	
Bias current change	$V_I = 13$ V to 24 V	0°C to 125°C			1.5			1.5	mA
	$I_O = 1$ mA to 40 mA				0.1			0.2	

μ A78L10AC, μ A78L10C electrical characteristics at specified virtual junction temperature,
 $V_I = 17$ V, $I_O = 40$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A78L10AC			μ A78L10C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$V_I = 13$ V to 25 V, $I_O = 1$ mA to 40 mA	25°C	9.6	10	10.4	9.2	10	10.8	V
	$I_O = 1$ mA to 70 mA	0°C to 125°C	9.5		10.5	9		10	
			9.5		10.5	9		10	
Input regulation	$V_I = 13$ V to 25 V	25°C		51	175		51	225	mV
	$V_I = 14$ V to 25 V			42	125		42	175	
Ripple rejection	$V_I = 14$ V to 25 V, $f = 120$ Hz	25°C	37	44		36	44		dB
Output regulation	$I_O = 1$ mA to 100 mA	25°C		20	90		20	90	mV
	$I_O = 1$ mA to 40 mA			11	40		11	40	
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C		62			62		μ V
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		4.2	6		4.2	6	mA
		125°C			5.5			5.5	
Bias current change	$V_I = 14$ V to 25 V	0°C to 125°C			1.5			1.5	mA
	$I_O = 1$ mA to 40 mA				0.1			0.2	

2

† All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

SERIES μ A78L00

POSITIVE-VOLTAGE REGULATORS

μ A78L12AC, μ A78L12C electrical characteristics at specified virtual junction temperature,
 $V_I = 19$ V, $I_O = 40$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A78L12AC			μ A78L12C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage		25° C	11.5	12	12.5	11.1	12	12.9	V
	$V_I = 14.5$ V to 27 V, $I_O = 1$ mA to 40 mA	0° C to 125° C	11.4		12.6	10.8		13.2	
	$I_O = 1$ mA to 70 mA		11.4		12.6	10.8		13.2	
Input regulation	$V_I = 14.5$ V to 27 V	25° C		55	250		55	250	mV
	$V_I = 16$ V to 27 V			49	200		49	200	
Ripple rejection	$V_I = 15$ V to 25 V, $f = 120$ Hz	25° C	37	42		36	42		dB
Output regulation	$I_O = 1$ mA to 100 mA	25° C		22	100		22	100	mV
	$I_O = 1$ mA to 40 mA			13	50		13	50	
Output noise voltage	$f = 10$ Hz to 100 kHz	25° C		70			70		μ V
Dropout voltage		25° C		1.7			1.7		V
Bias current		25° C		4.3	6.5		4.3	6.5	mA
		125° C			6			6	
Bias current change	$V_I = 16$ V to 27 V	0° C to 125° C			1.5			1.5	mA
	$I_O = 1$ mA to 40 mA				0.1			0.2	

μ A78L15AC, μ A78L15C electrical characteristics at specified virtual junction temperature,
 $V_I = 23$ V, $I_O = 40$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A78L15AC			μ A78L15C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage		25° C	14.4	15	15.6	13.8	15	16.2	V
	$V_I = 17.5$ V to 30 V, $I_O = 1$ mA to 40 mA	0° C to 125° C	14.25		15.75	13.5		16.5	
	$I_O = 1$ mA to 70 mA		14.25		15.75	13.5		16.5	
Input regulation	$V_I = 17.5$ V to 30 V	25° C		65	300		65	300	mV
	$V_I = 20$ V to 30 V			58	250		58	250	
Ripple rejection	$V_I = 18.5$ V to 28.5 V, $f = 120$ Hz	25° C	34	39		33	39		dB
Output regulation	$I_O = 1$ mA to 100 mA	25° C		25	150		25	150	mV
	$I_O = 1$ mA to 40 mA			15	75		15	75	
Output noise voltage	$f = 10$ Hz to 100 kHz	25° C		82			82		μ V
Dropout voltage		25° C		1.7			1.7		V
Bias current		25° C		4.6	6.5		4.6	6.5	mA
		125° C			6			6	
Bias current change	$V_I = 20$ V to 30 V	0° C to 125° C			1.5			1.5	mA
	$I_O = 1$ mA to 40 mA				0.1			0.2	

† All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

- 3-Terminal Regulators
- Output Current up to 500 mA
- No External Components
- Internal Thermal Overload Protection
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Direct Replacements for Fairchild μ A78M00 Series and National LM78MXX and LM341 Series

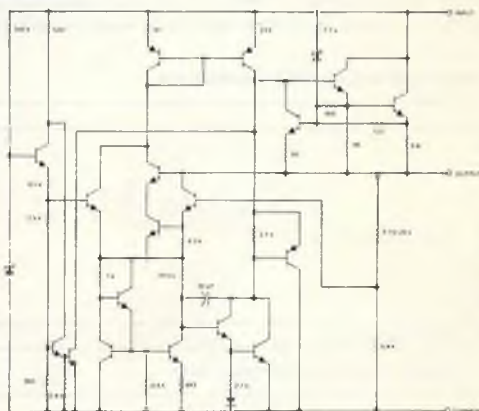
NOMINAL OUTPUT VOLTAGE	-55°C to 150°C OPERATING TEMPERATURE RANGE	0°C to 125°C OPERATING TEMPERATURE RANGE
5 V	μ A78M05M	μ A78M05C
6 V	μ A78M06M	μ A78M06C
8 V	μ A78M08M	μ A78M08C
10 V	μ A78M10M	μ A78M10C
12 V	μ A78M12M	μ A78M12C
15 V	μ A78M15M	μ A78M15C
20 V	μ A78M20M	μ A78M20C
24 V		μ A78M24C
PACKAGES	JG	KC

description

This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 500 milliamperes of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also as the power pass element in precision regulators.

terminal assignments

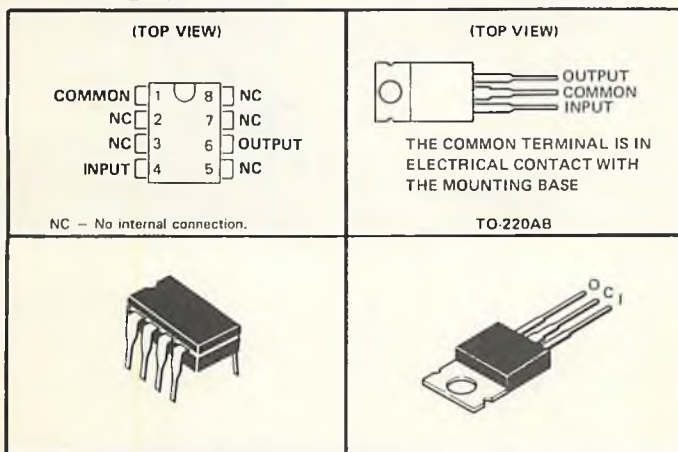
schematic



Resistor values shown are nominal and in ohms.

μ A78M_M... JG PACKAGE

μ A78M_C... KC PACKAGE



SERIES μ A78M00

POSITIVE-VOLTAGE REGULATORS

absolute maximum ratings over operating temperature range (unless otherwise noted)

		μ A78M05M THRU μ A78M24M	μ A78M05C THRU μ A78M24C	UNIT
Input voltage	μ A78M20 thru μ A78M24	40	40	V
	All others	35	35	
Continuous total dissipation at 25°C free-air temperature (see Note 1)	JG package	1.05		W
	KC (TO-220AB) package		2	
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	KC package		7.5	W
Operating free-air, case, or virtual junction temperature range		-55 to 150	0 to 150	°C
Storage temperature range		-65 to 150	-65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	JG package	300		°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	KC package		260	°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Curves, Figures 1 through 3.

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	μ A78M05M, μ A78M05C	7	25	V
	μ A78M06M, μ A78M06C	8	25	
	μ A78M08M, μ A78M08C	10.5	25	
	μ A78M10M, μ A78M10C	12.5	28	
	μ A78M12M, μ A78M12C	14.5	30	
	μ A78M15M, μ A78M15C	17.5	30	
	μ A78M20C	23	35	
	μ A78M24C	27	38	
Output current, I_O	All devices		500	mA
Operating virtual junction temperature, T_J	μ A78M05M thru μ A78M15M	-55	150	°C
	μ A78M05C thru μ A78M24C	0	125	

$\mu A78M05M$, $\mu A78M05C$ electrical characteristics at specified virtual junction temperature,
 $V_I = 10$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS [†]			$\mu A78M05M$			$\mu A78M05C$			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 350 mA	$V_I = 8$ V to 20 V	25°C	4.8	5	5.2	4.8	5	5.2	V
		$V_I = 7$ V to 20 V	-55°C to 150°C	4.7		5.3				
		$V_I = 7$ V to 25 V	0°C to 125°C				4.75		5.25	
Input regulation	$I_O = 200$ mA	$V_I = 7$ V to 25 V	25°C		3	50		3	100	mV
		$V_I = 8$ V to 20 V			1	25				
		$V_I = 8$ V to 25 V								
		$V_I = 8$ V to 25 V					1		50	
Ripple rejection	$V_I = 8$ V to 18 V, $f = 120$ Hz	$I_O = 100$ mA	-55°C to 150°C	62						dB
			0°C to 125°C				62			
		$I_O = 300$ mA	25°C	62	80		62	80		
Output regulation	$I_O = 5$ mA to 500 mA	25°C			20	50		20	100	mV
	$I_O = 5$ mA to 200 mA				10	25		10	50	
Temperature coefficient of output voltage	$I_O = 5$ mA	-55°C to 25°C				-2				mV/°C
		25°C to 150°C				-1.5				
		0°C to 125°C					-1			
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C			40	200		40	200	μ V
Dropout voltage		25°C			2	2.5		2	2.5	V
Bias current		25°C			4.5	7		4.5	6	mA
Bias current change	$I_O = 200$ mA, $V_I = 8$ V to 25 V	-55°C to 150°C				0.8				mA
		0°C to 125°C							0.8	
	$I_O = 5$ mA to 350 mA	-55°C to 150°C				0.5				
		0°C to 125°C							0.5	
Short-circuit output current	$V_I = 35$ V	25°C			300	600		300		mA
Peak output current		25°C		0.5	0.7	1.4		0.7		A

[†] All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

$\mu A78M06M$, $\mu A78M06C$ electrical characteristics at specified virtual junction temperature,
 $V_I = 11$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS ¹			$\mu A78M06M$			$\mu A78M06C$			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 350 mA	$V_I = 9$ V to 21 V	25 °C	5.75	6	6.25	5.75	6	6.25	V
		$V_I = 8$ V to 21 V	-55 °C to 150 °C	5.7		6.3				
			0 °C to 125 °C				5.7		6.3	
Input regulation	$I_O = 200$ mA	$V_I = 8$ V to 25 V	25 °C		5	60		5	100	mV
		$V_I = 9$ V to 20 V			1.5	30				
		$V_I = 9$ V to 25 V					1.5		50	
Ripple rejection	$V_I = 9$ V to 19 V, $f = 120$ Hz	$I_O = 100$ mA	-55 °C to 150 °C	59						dB
			0 °C to 125 °C				59			
		$I_O = 300$ mA	25 °C	59	80		59	80		
Output regulation	$I_O = 5$ mA to 500 mA		25 °C		20	60		20	120	mV
	$I_O = 5$ mA to 200 mA				10	30		10	60	
Temperature coefficient of output voltage	$I_O = 5$ mA		-55 °C to 25 °C			-2.4				mV/°C
			25 °C to 150 °C			-1.8				
			0 °C to 125 °C				-1			
Output noise voltage	$f = 10$ Hz to 100 kHz		25 °C		45	240		45		μ V
Dropout voltage			25 °C		2	2.5		2		V
Bias current			25 °C		4.5	7		4.5	6	mA
Bias current change	$I_O = 200$ mA, $V_I = 9$ V to 25 V		-55 °C to 150 °C			0.8				mA
			0 °C to 125 °C						0.8	
	$I_O = 5$ mA to 350 mA		-55 °C to 150 °C			0.5				
			0 °C to 125 °C						0.5	
Short-circuit output current	$V_I = 35$ V		25 °C		270	600		270		mA
Peak output current			25 °C	0.5	0.7	1.4		0.7		A

¹All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

$\mu A78M08M$, $\mu A78M08C$ electrical characteristics at specified virtual junction temperature,
 $V_I = 14$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS ¹			$\mu A78M08M$			$\mu A78M08C$			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 350 mA	$V_I = 11.5$ V to 23 V	-55°C to 150°C	7.7	8	8.3	7.7	8	8.3	V
		$V_I = 10.5$ V to 23 V	0°C to 125°C	7.6		8.4				
							7.6		8.4	
Input regulation	$I_O = 200$ mA	$V_I = 10.5$ V to 25 V	25°C		6	60		6	100	mV
		$V_I = 11$ V to 20 V			2	30				
		$V_I = 11$ V to 25 V					2	50		
Ripple rejection	$V_I = 11.5$ V to 21.5 V, $f = 120$ Hz	$I_O = 100$ mA	-55°C to 150°C	56						dB
			0°C to 125°C				56			
		$I_O = 300$ mA	25°C	56	80		56	80		
Output regulation	$I_O = 5$ mA to 500 mA	25°C			25	80		25	160	mV
	$I_O = 5$ mA to 200 mA				10	40		10	80	
Temperature coefficient of output voltage	$I_O = 5$ mA		-55°C to 25°C			-3.2				mV/ $^\circ\text{C}$
			25°C to 150°C			-2.4				
			0°C to 125°C					-1		
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C			52	320		52		μV
Dropout voltage		25°C			2	2.5		2		V
Bias current		25°C			4.6	7		4.6	6	mA
Bias current change	$I_O = 200$ mA,	$V_I = 11.5$ V to 25 V	-55°C to 150°C			0.8				mA
		$V_I = 10.5$ V to 25 V	0°C to 125°C					0.8		
	$I_O = 5$ mA to 350 mA		-55°C to 150°C			0.5				
			0°C to 125°C					0.5		
Short-circuit output current	$V_I = 35$ V	25°C			250	600		250		mA
Peak output current		25°C			0.5	0.7	1.4		0.7	A

¹ All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF . All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_W \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

μ A78M10M, μ A78M10C electrical characteristics at specified virtual junction temperature,
 $V_I = 17$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS [†]			μ A78M10M			μ A78M10C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 350 mA	$V_I = 13.5$ V to 25 V	-55°C to 150°C	9.6	10	10.4	9.6	10	10.4	V
		$V_I = 12.5$ V to 25 V	0°C to 125°C	9.5		10.5				
		$V_I = 12.5$ V to 28 V	0°C to 125°C				9.5		10.5	
Input regulation	$I_O = 200$ mA	$V_I = 12.5$ V to 28 V	25°C		7	60		7	100	mV
		$V_I = 14$ V to 20 V			2	30				
		$V_I = 14$ V to 28 V					2	50		
Ripple rejection	$V_I = 15$ V to 25 V, $f = 120$ Hz	$I_O = 100$ mA	-55°C to 150°C	55						dB
			0°C to 125°C				55			
		$I_O = 300$ mA	25°C	55	80		55	80		
Output regulation	$I_O = 5$ mA to 500 mA		25°C		25	100		25	200	mV
	$I_O = 5$ mA to 200 mA				10	50		10	100	
Temperature coefficient of output voltage	$I_O = 5$ mA		-55°C to 25°C			-4				mV/ $^\circ\text{C}$
			25°C to 150°C			-3				
			0°C to 125°C				-1			
Output noise voltage	$f = 10$ Hz to 100 kHz		25°C		64			64		μV
Dropout voltage			25°C		2	2.5		2		V
Bias current			25°C		4.7	6		4.7	6	mA
Bias current change	$I_O = 200$ mA,	$V_I = 13.5$ V to 28 V	-55°C to 150°C			0.8				mA
		$V_I = 12.5$ V to 28 V	0°C to 125°C					0.8		
	$I_O = 5$ mA to 350 mA		-55°C to 150°C			0.5				
			0°C to 125°C					0.5		
Short-circuit output current	$V_I = 35$ V		25°C		245	600		245		mA
Peak output current			25°C		0.5	0.7		0.7		A

[†]All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF . All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_W \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

μ A78M12M, μ A78M12C electrical characteristics at specified virtual junction temperature,
 $V_I = 19$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS [†]			μ A78M12M			μ A78M12C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 350 mA	$V_I = 15.5$ V to 27 V	25°C	11.5	12	12.5	11.5	12	12.5	V
		$V_I = 14.5$ V to 27 V	–55°C to 150°C	11.4		12.6				
		$V_I = 14.5$ V to 27 V	0°C to 125°C				11.4		12.6	
Input regulation	$I_O = 200$ mA	$V_I = 14.5$ V to 30 V	25°C		8	60		8	100	mV
		$V_I = 16$ V to 25 V			2	30				
		$V_I = 16$ V to 30 V					2	50		
Ripple rejection	$V_I = 15$ V to 25 V, $f = 120$ Hz	$I_O = 100$ mA	–55°C to 150°C	55						dB
			0°C to 125°C				55			
		$I_O = 300$ mA	25°C	55	80		55	80		
Output regulation	$I_O = 5$ mA to 500 mA		25°C		25	120		25	240	mV
	$I_O = 5$ mA to 200 mA				10	60		10	120	
Temperature coefficient of output voltage	$I_O = 5$ mA		–55°C to 25°C			–4.8				mV/°C
			25°C to 150°C			–3.6				
			0°C to 125°C				–1			
Output noise voltage	$f = 10$ Hz to 100 kHz		25°C		75	480		75		μ V
Dropout voltage			25°C		2	2.5		2		V
Bias current			25°C		4.8	7		4.8	6	mA
Bias current change	$I_O = 200$ mA	$V_I = 15$ V to 30 V	–55°C to 150°C			0.8				mA
		$V_I = 14.5$ V to 30 V	0°C to 125°C						0.8	
	$I_O = 5$ mA to 350 mA		–55°C to 150°C			0.5				
			0°C to 125°C						0.5	
Short-circuit output current	$V_I = 35$ V		25°C		240	600		240		mA
Peak output current			25°C	0.5	0.7	1.4		0.7		A

[†] All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulsed techniques ($t_W \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

$\mu A78M15M$, $\mu A78M15C$ electrical characteristics at specified virtual junction temperature,
 $V_I = 23$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS ¹			$\mu A78M15M$			$\mu A78M15C$			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 350 mA	$V_I = 18.5$ V to 30 V	25°C	14.4	15	15.6	14.4	15	15.6	V
		$V_I = 17.5$ V to 30 V	-55°C to 150°C	14.25		15.75				
		$V_I = 17.5$ V to 30 V	0°C to 125°C				14.25		15.75	
Input regulation	$I_O = 200$ mA	$V_I = 17.5$ V to 30 V	25°C		10	60		10	100	mV
		$V_I = 20$ V to 30 V			3	30		3	50	
Ripple rejection	$V_I = 18.5$ V to 28.5 V, $f = 120$ Hz	$I_O = 100$ mA	-55°C to 150°C	54						dB
			0°C to 125°C				54			
		$I_O = 300$ mA	25°C	54	70		54	70		
Output regulation	$I_O = 5$ mA to 500 mA		25°C		25	150		25	300	mV
	$I_O = 5$ mA to 200 mA				10	75		10	150	
Temperature coefficient of output voltage	$I_O = 5$ mA		-55°C to 25°C			-6				mV/°C
			25°C to 150°C			-4.5				
			0°C to 125°C				-1			
Output noise voltage	$f = 10$ Hz to 100 kHz		25°C		90	600		90		μV
Dropout voltage			25°C		2	2.5		2		V
Bias current			25°C		4.8	7		4.8	6	mA
Bias current change	$I_O = 200$ mA,	$V_I = 18.5$ V to 30 V	-55°C to 150°C			0.8				mA
		$V_I = 17.5$ V to 30 V	0°C to 125°C						0.8	
	$I_O = 5$ mA to 350 mA		-55°C to 150°C			0.5				
			0°C to 125°C						0.5	
Short-circuit output current	$V_I = 35$ V		25°C		240	600		240		mA
Peak output current			25°C		0.5	0.7		0.7		A

¹ All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

$\mu A78M20C$ electrical characteristics at specified virtual junction temperature,
 $V_I = 29$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA78M20C			UNIT
				MIN	TYP	MAX	
Output voltage			25°C	19.2	20	20.8	V
	$I_O = 5\text{ mA to }350\text{ mA},$	$V_I = 23\text{ V to }35\text{ V}$	0°C to 125°C	19		21	
Input regulation	$I_O = 200\text{ mA}$	$V_I = 23\text{ V to }35\text{ V}$	25°C		10	100	mV
		$V_I = 24\text{ V to }35\text{ V}$			5	50	
Ripple rejection	$V_I = 24\text{ V to }34\text{ V},$ $f = 120\text{ Hz}$	$I_O = 100\text{ mA}$	0°C to 125°C	53			dB
		$I_O = 300\text{ mA}$	25°C	53	70		
Output regulation	$I_O = 5\text{ mA to }500\text{ mA}$		25°C		30	400	mV
	$I_O = 5\text{ mA to }200\text{ mA}$				10	200	
Temperature coefficient of output voltage	$I_O = 5\text{ mA}$		0°C to 125°C	-1.1			mV/°C
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$		25°C	110			μV
Dropout voltage			25°C	2			V
Bias current			25°C	4.9		6	mA
Bias current change	$I_O = 200\text{ mA}, \quad V_I = 23\text{ V to }35\text{ V}$		0°C to 125°C	0.8			mA
	$I_O = 5\text{ mA to }350\text{ mA}$		0°C to 125°C	0.5			
Short-circuit output current	$V_I = 35\text{ V}$		25°C	240			mA
Peak output current			25°C	0.7			A

[†] All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

μ A78M24C electrical characteristics at specified virtual junction temperature,
 $V_I = 33$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			μ A78M24C			UNIT
				MIN	TYP	MAX	
Output voltage	25°C			23	24	25	V
	$I_O = 5$ mA to 350 mA,	$V_I = 27$ V to 38 V	0°C to 125°C	22.8		25.2	
Input regulation	$I_O = 200$ mA	$V_I = 27$ V to 38 V			10	100	mV
		$V_I = 28$ V to 38 V			5	50	
Ripple rejection	$V_I = 28$ V to 38 V, $f = 120$ Hz	$I_O = 100$ mA	-55°C to 150°C				dB
			0°C to 125°C		50		
		$I_O = 300$ mA	25°C	50	70		
Output regulation	$I_O = 5$ mA to 500 mA		25°C		30	480	mV
	$I_O = 5$ mA to 200 mA				10	240	
Temperature coefficient of output voltage	$I_O = 5$ mA		0°C to 125°C	-1.2			mV/°C
Output noise voltage	$f = 10$ Hz to 100 kHz		25°C		170		μ V
Dropout voltage			25°C		2		V
Bias current			25°C		5	8	mA
Bias current change	$I_O = 200$ mA,	$V_I = 27$ V to 38 V	0°C to 125°C			0.8	mA
	$I_O = 5$ mA to 350 mA		0°C to 125°C			0.5	
Short-circuit output current	$V_I = 35$ V		25°C		240		mA
Peak output current			25°C		0.7		A

† All characteristics are measured with a capacitor across the input of 0.33 μ F and a capacitor across the output of 0.1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_W \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

THERMAL INFORMATION

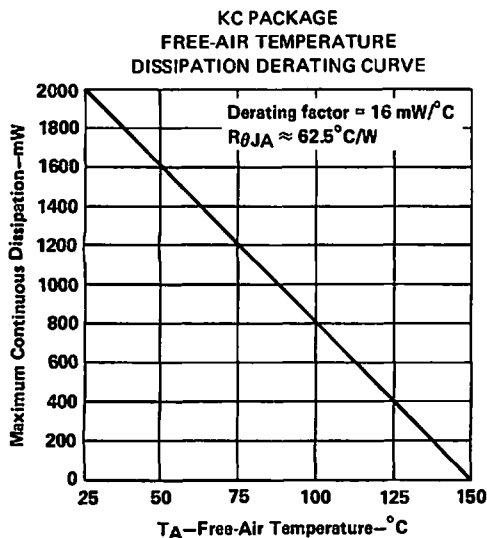


FIGURE 1

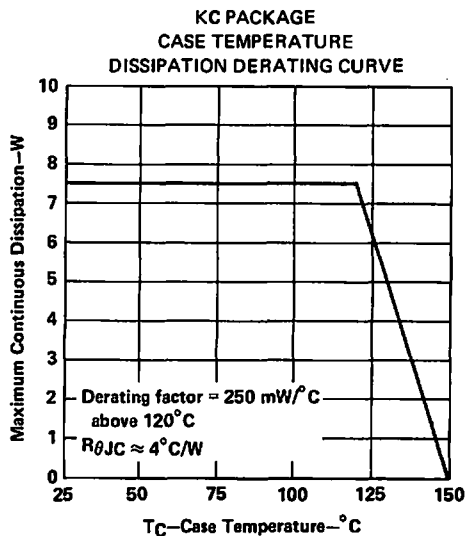


FIGURE 2

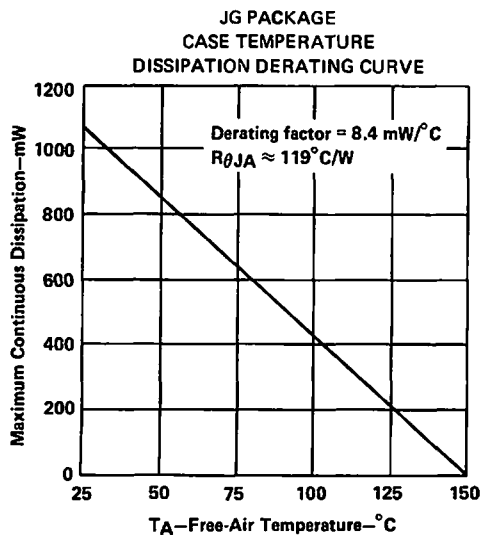


FIGURE 3

2

2017年12月15日 2017年12月15日

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2017年12月15日 2017年12月15日

- 3-Terminal Regulators
- Output Current up to 1.5 A
- No External Components
- Internal Thermal Overload Protection
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Essentially Equivalent to National LM320 Series
- Direct Replacements for Fairchild μ A7900 Series and National LM79XX Series

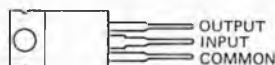
NOMINAL OUTPUT VOLTAGE	REGULATOR
-5 V	μ A7905C
-5.2 V	μ A7952C
-6 V	μ A7906C
-8 V	μ A7908C
-12 V	μ A7912C
-15 V	μ A7915C
-18 V	μ A7918C
-24 V	μ A7924C

description

This series of fixed-negative-voltage monolithic integrated-circuit voltage regulators is designed to complement Series μ A7800 in a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 amperes of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also as the power pass element in precision regulators.

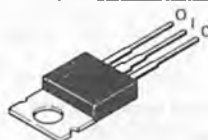
KC PACKAGE

(TOP VIEW)

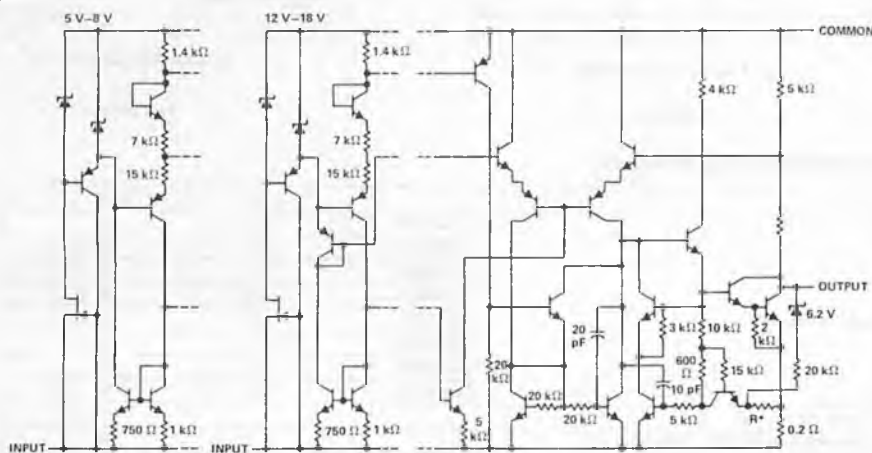


THE INPUT TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



schematic



12 V-18 V; $R^* \approx 50 \Omega$

5 V-8 V; $R^* \approx 150 \Omega$

All component values are nominal.

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TEXAS INSTRUMENTS
INCORPORATED

POST OFFICE BOX 225012 • DALLAS, TEXAS 75265

SERIES μ A7900

POSITIVE-VOLTAGE REGULATORS

absolute maximum ratings over operating temperature range (unless otherwise noted)

		μ A7905C THRU μ A7924C	UNIT
Input voltage	μ A7924C	-40	V
	All others	-35	
Continuous total dissipation at 25°C free-air temperature (see Note 1)		2	W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)		15	W
Operating free-air, case, or virtual junction temperature range		0 to 150	°C
Storage temperature range		-65 to 150	°C
Lead temperature 3.2 mm (1/8 inch) from case for 10 seconds		260	°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Curves, Figure 1 and Figure 2.

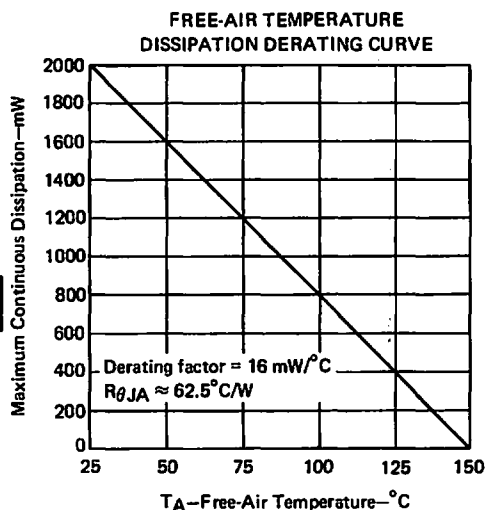


FIGURE 1

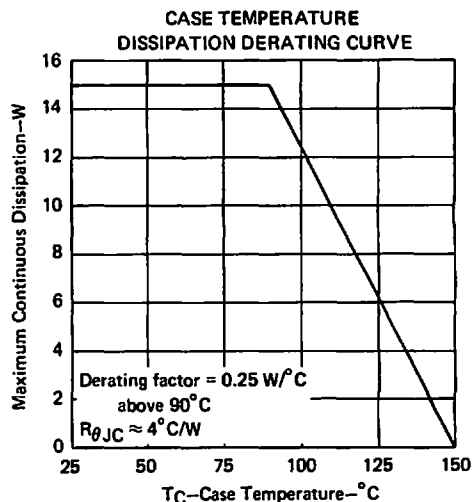


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_i	μ A7905C	-7	-25	V
	μ A7952C	-7.2	-25	
	μ A7906C	-8	-25	
	μ A7908C	-10.5	-25	
	μ A7912C	-14.5	-30	
	μ A7915C	-17.5	-30	
	μ A7918C	-21	-33	
	μ A7924C	-27	-38	
Output current, I_O			1.5	A
Operating virtual junction temperature, T_J		0	125	°C

TYPES μ A7905C, μ A7952C NEGATIVE-VOLTAGE REGULATORS

μ A7905C electrical characteristics at specified virtual junction temperature,
 $V_I = -10$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μA7905C			UNIT
			MIN	TYP	MAX	
Output voltage	$I_O = 5\text{ mA to }1\text{ A},$ $V_I = -7\text{ V to }-20\text{ V},$ $P < 15\text{ W}$	25°C	-4.8	-5	-5.2	V
		$0^\circ\text{C to }125^\circ\text{C}$	-4.75		-5.25	
Input regulation	$V_I = -7\text{ V to }-25\text{ V}$	25°C		12.5	50	mV
	$V_I = -8\text{ V to }-12\text{ V}$			4	15	
Ripple rejection	$V_I = -8\text{ V to }-18\text{ V},$ $f = 120\text{ Hz}$	$0^\circ\text{C to }125^\circ\text{C}$	54	60		dB
Output regulation	$I_O = 5\text{ mA to }1.5\text{ A}$	25°C		15	100	mV
	$I_O = 250\text{ mA to }750\text{ mA}$			5	50	
Temperature coefficient of output voltage	$I_O = 5\text{ mA}$	$0^\circ\text{C to }125^\circ\text{C}$		-0.4		mV/°C
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C		125		μV
Dropout voltage	$I_O = 1\text{ A}$	25°C		1.1		V
Bias current		25°C		1.5	2	mA
Bias current change	$V_I = -7\text{ V to }-25\text{ V}$	$0^\circ\text{C to }125^\circ\text{C}$		0.15	0.5	mA
	$I_O = 5\text{ mA to }1\text{ A}$			0.08	0.5	
Peak output current		25°C		2.1		A

μ A7952C electrical characteristics at specified virtual junction temperature,
 $V_I = -10$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7952C			UNIT
			MIN	TYP	MAX	
Output voltage	$I_O = 5 \text{ mA to } 1 \text{ A,}$ $P < 15 \text{ W}$ $V_I = -7.2 \text{ V to } -20 \text{ V,}$	25°C	-5	-5.2	-5.4	V
		0°C to 125°C	-4.95		-5.45	
Input regulation	$V_I = -7.2 \text{ V to } -25 \text{ V}$	25°C		12.5	100	mV
	$V_I = -8.2 \text{ V to } -12 \text{ V}$			4	50	
Ripple rejection	$V_I = -8.2 \text{ V to } -18 \text{ V,}$ $f = 120 \text{ Hz}$	0°C to 125°C	54	60		dB
Output regulation	$I_O = 5 \text{ mA to } 1.5 \text{ A}$	25°C		15	100	mV
	$I_O = 250 \text{ mA to } 750 \text{ mA}$			5	50	
Temperature coefficient of output voltage	$I_O = 5 \text{ mA}$	0°C to 125°C		-0.4		mV/°C
Output noise voltage	$f = 10 \text{ Hz to } 100 \text{ kHz}$	25°C		125		μV
Dropout voltage	$I_O = 1 \text{ A}$	25°C		1.1		V
Bias current		25°C		1.5	2	mA
Bias current change	$V_I = -7.2 \text{ V to } -25 \text{ V}$	0°C to 125°C		0.15	1.3	mA
	$I_O = 5 \text{ mA to } 1 \text{ A}$			0.08	0.5	
Peak output current		25°C		2.1		A

† All characteristics are measured with a solid-tantalum capacitor across the input of $2\ \mu\text{F}$ and a solid-tantalum capacitor across the output of $1\ \mu\text{F}$. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPES μ A7906C, μ A7908C

NEGATIVE-VOLTAGE REGULATORS

μ A7906C electrical characteristics at specified virtual junction temperature,
 $V_I = -11$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A7906C			UNIT
			MIN	TYP	MAX	
Output voltage		25°C	-5.75	-6	-6.25	V
	$I_O = 5$ mA to 1 A, $V_I = -8$ V to -21 V, $P < 15$ W	0°C to 125°C	-5.7		-6.3	
Input regulation	$V_I = -8$ V to -25 V	25°C		12.5	120	mV
	$V_I = -9$ V to -13 V			4	60	
Ripple rejection	$V_I = -9$ V to -19 V, $f = 120$ Hz	0°C to 125°C	54	60		dB
Output regulation	$I_O = 5$ mA to 1.5 A	25°C		15	120	mV
	$I_O = 250$ mA to 750 mA			5	60	
Temperature coefficient of output voltage	$I_O = 5$ mA	0°C to 125°C		-0.4		mV/°C
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C		150		μ V
Dropout voltage	$I_O = 1$ A	25°C		1.1		V
Bias current		25°C		1.5	2	mA
Bias current change	$V_I = -8$ V to -25 V	0°C to 125°C		0.15	1.3	mA
	$I_O = 5$ mA to 1 A			0.08	0.5	
Peak output current		25°C		2.1		A

μ A7908C electrical characteristics at specified virtual junction temperature,
 $V_I = -14$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A7908C			UNIT
			MIN	TYP	MAX	
Output voltage		25°C	-7.7	-8	-8.3	V
	$I_O = 5$ mA to 1 A, $V_I = -10.5$ V to -23 V, $P < 15$ W	0°C to 125°C	-7.6		-8.4	
Input regulation	$V_I = -10.5$ V to -25 V	25°C		12.5	160	mV
	$V_I = -11$ V to -17 V			4	80	
Ripple rejection	$V_I = -11.5$ V to -21.5 V, $f = 120$ Hz	0°C to 125°C	54	60		dB
Output regulation	$I_O = 5$ mA to 1.5 A	25°C		15	160	mV
	$I_O = 250$ mA to 750 mA			5	80	
Temperature coefficient of output voltage	$I_O = 5$ mA	0°C to 125°C		-0.6		mV/°C
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C		200		μ V
Dropout voltage	$I_O = 1$ A	25°C		1.1		V
Bias current		25°C		1.5	2	mA
Bias current change	$V_I = -10.5$ V to -25 V	0°C to 125°C		0.15	1	mA
	$I_O = 5$ mA to 1 A			0.08	0.5	
Peak output current		25°C		2.1		A

† All characteristics are measured with a solid-tantalum capacitor across the input of 2 μ F and a solid-tantalum capacitor across the output of 1 μ F. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPES μ A7912C, μ A7915C NEGATIVE-VOLTAGE REGULATORS

μ A7912C electrical characteristics at specified virtual junction temperature,
 $V_I = -19$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7912C			UNIT
			MIN	TYP	MAX	
Output voltage	$I_O = 5 \text{ mA to } 1 \text{ A},$ $V_I = -14.5 \text{ V to } -27 \text{ V},$ $P < 15 \text{ W}$	25°C	-11.5	-12	-12.5	V
		0°C to 125°C	-11.4		-12.6	
Input regulation	$V_I = -14.5 \text{ V to } -30 \text{ V}$	25°C		5	80	mV
	$V_I = -16 \text{ V to } -22 \text{ V}$			3	30	
Ripple rejection	$V_I = -15 \text{ V to } -25 \text{ V},$ $f = 120 \text{ Hz}$	0°C to 125°C	54	60		dB
Output regulation	$I_O = 5 \text{ mA to } 1.5 \text{ A}$	25°C		15	200	mV
	$I_O = 250 \text{ mA to } 750 \text{ mA}$			5	75	
Temperature coefficient of output voltage	$I_O = 5 \text{ mA}$	0°C to 125°C		-0.8		mV/°C
Output noise voltage	$f = 10 \text{ Hz to } 100 \text{ kHz}$	25°C		300		μV
Dropout voltage	$I_O = 1 \text{ A}$	25°C		1.1		V
Bias current		25°C		2	3	mA
Bias current change	$V_I = -14.5 \text{ V to } -30 \text{ V}$	0°C to 125°C		0.04	0.5	mA
	$I_O = 5 \text{ mA to } 1 \text{ A}$			0.06	0.5	
Peak output current		25°C		2.1		A

μ A7915C electrical characteristics at specified virtual junction temperature,
 $V_I = -23$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7915C			UNIT
			MIN	TYP	MAX	
Output voltage	$I_O = 5\text{ mA to }1\text{ A}, \quad V_I = -17.5\text{ V to }-30\text{ V},$ $P < 15\text{ W}$	25°C	-14.4	-15	-15.6	V
		$0^\circ\text{C to }125^\circ\text{C}$	-14.25		-15.75	
Input regulation	$V_I = -17.5\text{ V to }-30\text{ V}$	25°C		5	100	mV
	$V_I = -20\text{ V to }-26\text{ V}$			3	50	
Ripple rejection	$V_I = -18.5\text{ V to }-28.5\text{ V}, \quad f = 120\text{ Hz}$	$0^\circ\text{C to }125^\circ\text{C}$	54	60		dB
Output regulation	$I_O = 5\text{ mA to }1.5\text{ A}$	25°C		15	200	mV
	$I_O = 250\text{ mA to }750\text{ mA}$			5	75	
Temperature coefficient of output voltage	$I_O = 5\text{ mA}$	$0^\circ\text{C to }125^\circ\text{C}$		-1		mV/°C
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C		375		μV
Dropout voltage	$I_O = 1\text{ A}$	25°C		1.1		V
Bias current		25°C		2	3	mA
Bias current change	$V_I = -17.5\text{ V to }-30\text{ V}$	$0^\circ\text{C to }125^\circ\text{C}$		0.04	0.5	mA
	$I_O = 5\text{ mA to }1\text{ A}$			0.06	0.5	
Peak output current		25°C		2.1		A

† All characteristics are measured with a solid-tantalum capacitor across the input of $2\ \mu\text{F}$ and a solid-tantalum capacitor across the output of $1\ \mu\text{F}$. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPES μ A7918C, μ A7924C

NEGATIVE-VOLTAGE REGULATORS

μ A7918C electrical characteristics at specified virtual junction temperature,
 $V_I = -27$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	μA7918C			UNIT	
		MIN	TYP	MAX		
Output voltage	$I_O = 5\text{ mA to }1\text{ A}, \quad V_I = -21\text{ V to }-33\text{ V},$ $P < 15\text{ W}$	25°C	-17.3	-18	-18.7	V
		0°C to 125°C	-17.1		-18.9	
Input regulation	$V_I = -21\text{ V to }-33\text{ V}$	25°C		5	360	mV
	$V_I = -24\text{ V to }-30\text{ V}$			3	180	
Ripple rejection	$V_I = -22\text{ V to }-32\text{ V}, \quad f = 120\text{ Hz}$	0°C to 125°C	54	60		dB
Output regulation	$I_O = 5\text{ mA to }1.5\text{ A}$	25°C		30	360	mV
	$I_O = 250\text{ mA to }750\text{ mA}$			10	180	
Temperature coefficient of output voltage	$I_O = 5\text{ mA}$	0°C to 125°C		-1		mV/°C
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C		450		μV
Dropout voltage	$I_O = 1\text{ A}$	25°C		1.1		V
Bias current		25°C		2	3	mA
Bias current change	$V_I = -21\text{ V to }-33\text{ V}$	0°C to 125°C		0.04	1	mA
	$I_O = 5\text{ mA to }1\text{ A}$			0.06	0.5	
Peak output current		25°C		2.1		A

μ A7924C electrical characteristics at specified virtual junction temperature,
 $V_I = -33$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	uA7924C			UNIT	
		MIN	TYP	MAX		
Output voltage	$I_O = 5\text{ mA to }1\text{ A}, \quad V_I = -27\text{ V to }-38\text{ V},$ $P < 15\text{ W}$	25°C	-23	-24	-25	V
		0°C to 125°C	-22.8		-25.2	
Input regulation	$V_I = -27\text{ V to }-38\text{ V}$	25°C		5	480	mV
	$V_I = -30\text{ V to }-36\text{ V}$			3	240	
Ripple rejection	$V_I = -28\text{ V to }-38\text{ V}, \quad f = 120\text{ Hz}$	0°C to 125°C	54	60		dB
Output regulation	$I_O = 5\text{ mA to }1.5\text{ A}$	25°C		85	480	mV
	$I_O = 250\text{ mA to }750\text{ mA}$			25	240	
Temperature coefficient of output voltage	$I_O = 5\text{ mA}$	0°C to 125°C		-1		mV/°C
Output noise voltage	$f = 10\text{ Hz to }100\text{ kHz}$	25°C		600		μV
Dropout voltage	$I_O = 1\text{ A}$	25°C		1.1		V
Bias current		25°C		2	3	mA
Bias current change	$V_I = -27\text{ V to }-38\text{ V}$	0°C to 125°C		0.04	1	mA
	$I_O = 5\text{ mA to }1\text{ A}$			0.06	0.5	
Peak output current		25°C		2.1		A

† All characteristics are measured with a solid-tantalum capacitor across the input of 2 μF and a solid-tantalum capacitor across the output of 1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

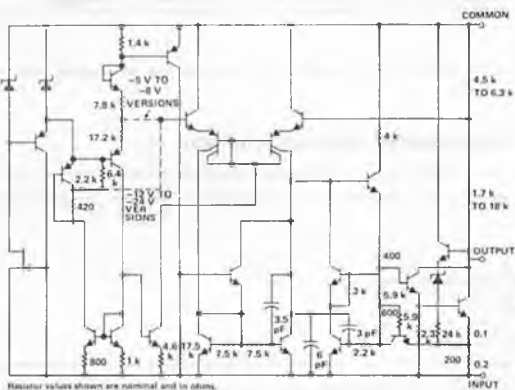
- 3-Terminal Regulators
- Output Current up to 500 mA
- No External Components
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Direct Replacements for Fairchild μ A79M00 Series

NOMINAL OUTPUT VOLTAGE	-55°C TO 150°C OPERATING TEMPERATURE RANGE	0°C TO 125°C OPERATING TEMPERATURE RANGE
-5 V	μ A79M05M	μ A79M05C
-6 V	μ A79M06M	μ A79M06C
-8 V	μ A79M08M	μ A79M08C
-12 V	μ A79M12M	μ A79M12C
-15 V	μ A79M15M	μ A79M15C
-20 V		μ A79M20C
-24 V		μ A79M24C
PACKAGE	JG	KC

description

This series of fixed-negative-voltage monolithic integrated-circuit voltage regulators is designed to complement Series μ A78M00 in a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 500 milliamperes of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also as the power pass element in precision regulators.

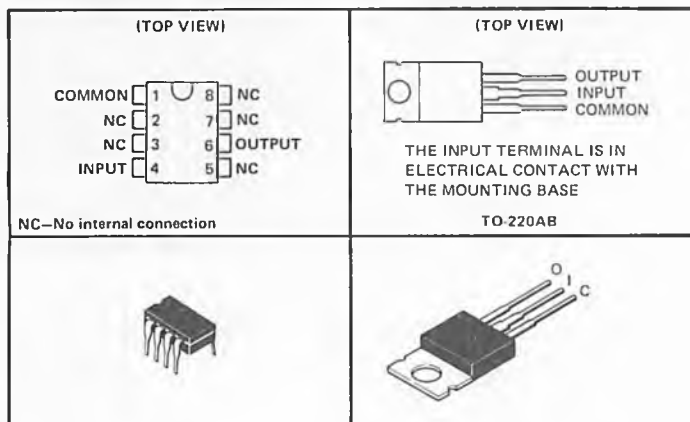
schematic



terminal assignments

μ A79M_M...JG PACKAGE

μ A79M_C...KC PACKAGE



SERIES μ A79M00

NEGATIVE-VOLTAGE REGULATORS

absolute maximum ratings over operating temperature range (unless otherwise noted)

		μ A78M05M THRU μ A79M15M	μ A78M05C THRU μ A79M24C	UNIT
Input voltage	μ A79M20, μ A79M24		-40	V
	All others	-35	-35	
Continuous total dissipation at 25°C free-air temperature (see Note 1)	JG package	1.05		W
	KC (TO-220AB) package		2	
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	KC package		7.5	W
Operating free-air, case or virtual junction temperature range		-55 to 150	0 to 150	°C
Storage temperature range		-65 to 150	-65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	JG package	300		°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	KC package		260	°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Curves, Figures 1 through 4, page 188.

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	uA79M05M, uA79M05C	-7	-25	V
	uA79M06M, uA79M06C	-8	-25	
	uA79M08M, uA79M08C	-10.5	-25	
	uA79M12M, uA79M12C	-14.5	-30	
	uA79M15M, uA79M15C	-17.5	-30	
	uA79M20C	-23	-35	
	uA79M24C	-27	-38	
Output current, I_O			500	mA
Operating virtual junction temperature, T_J	uA79M05M thru uA79M15M	-55	150	°C
	uA79M05C thru uA79M24C	0	125	

TYPES μ A79M05M, μ A79M05C **NEGATIVE-VOLTAGE REGULATORS**

μ A79M05M, μ A79M05C electrical characteristics at specified virtual junction temperature,
 $V_I = -10$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA79M05M			uA79M05C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage			25°C			-4.8 -5 -5.2			V
	I _O = 5 mA to 350 mA, V _I = -7 V to -25 V		-55°C to 150°C			-4.75 -5.25			
			0°C to 125°C			-4.75 -5.25			
Input regulation	V _I = -7 V to -25 V		25°C			7 50			mV
	V _I = -8 V to -18 V					3 30			
Ripple rejection	V _I = -8 V to -18 V, f = 120 Hz	I _O = 100 mA	-55°C to 150°C			50			dB
			0°C to 125°C			50			
		I _O = 300 mA	25°C			54 60			
Output regulation	I _O = 5 mA to 500 mA		25°C			75 100			mV
	I _O = 5 mA to 350 mA					50			
Temperature coefficient of output voltage	I _O = 5 mA		-55°C to 150°C			-1.5			mV/°C
			0°C to 125°C			-0.4			
Output noise voltage	f = 10 Hz to 100 kHz		25°C			125 400			μV
Dropout voltage			25°C			1.1 2.3			V
Bias current			25°C			1 2			mA
Bias current change	V _I = -8 V to -25 V		-55°C to 150°C			0.4			mA
			0°C to 125°C			0.4			
			-55°C to 150°C			0.4			
			0°C to 125°C			0.4			
Short-circuit output current	V _I = -30 V		25°C			600 140			mA
Peak output current			25°C			0.5 0.65 1.4 0.65			A

† All characteristics are measured with a 2- μ F capacitor across the input and a 1- μ F capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

TYPES μ A79M06M, μ A79M06C NEGATIVE-VOLTAGE REGULATORS

μ A79M06M, μ A79M06C electrical characteristics at specified virtual junction temperature,
 $V_I = -11$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μA79M06M			μA79M06C			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
Output voltage			25°C	-5.75	-6	-6.25	-5.75	-6	-6.25	V
	I _O = 5 mA to 350 mA, V _I = -8 V to -25 V		-55°C to 150°C	-5.7		-6.3				
			0°C to 125°C			-5.7		-6.3		
Input regulation	V _I = -8 V to -25 V		25°C	7		60		7	60	mV
	V _I = -9 V to -19 V			3		40		3	40	
Ripple rejection	V _I = -9 V to -19 V, f = 120 Hz	I _O = 100 mA	-55°C to 150°C	50						dB
			0°C to 125°C			50				
		I _O = 300 mA	25°C	64	60	54	60			
Output regulation	I _O = 5 mA to 500 mA		25°C	80		120		80	120	mV
	I _O = 5 mA to 350 mA			55		55				
Temperature coefficient of output voltage	I _O = 5 mA		-55°C to 150°C	-1.5						mV/°C
			0°C to 125°C			-0.4				
Output noise voltage	f = 10 Hz to 100 kHz		25°C	150		480		150		μV
Dropout voltage			25°C	1.1		2.3		1.1		V
Bias current			25°C	1		2		1	2	mA
Bias current change	V _I = -9 V to -25 V		-55°C to 150°C	0.4						mA
			0°C to 125°C					0.4		
	I _O = 6 mA to 350 mA	-55°C to 150°C	0.4							
		0°C to 125°C			0.4					
Short-circuit output current	V _I = -30 V		25°C	600		140				mA
Peak output current			25°C	0.5	0.65	1.4	0.65			A

† All characteristics are measured with a 2- μ F capacitor across the input and a 1- μ F capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPES μ A79M08M, μ A79M08C **NEGATIVE-VOLTAGE REGULATORS**

μ A79M08M, μ A79M08C electrical characteristics at specified virtual junction temperature,
 $V_I = -19$ V, $I_O = 350$ mA (unless noted)

PARAMETER	TEST CONDITIONS†		μ A79M08M			μ A79M08C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 350 mA, $V_I = -10.5$ V to -25 V	25°C	-7.7	-8	-8.3	-7.7	-8	-8.3	V
		-55°C to 150°C	-7.6		-8.4				
		0°C to 125°C				-7.6		-8.4	
Input regulation	$V_I = -10.5$ V to -25 V	25°C		8	80		8	80	mV
	$V_I = -11$ V to -21 V			4	50		4	50	
Ripple rejection	$V_I = -11.5$ V to -21.5 V, $f = 120$ Hz	-55°C to 150°C		50					dB
		0°C to 125°C				50			
	$I_O = 100$ mA $I_O = 300$ mA	25°C		54	59		54	59	
Output regulation	$I_O = 5$ mA to 500 mA	25°C		90	160		90	160	mV
	$I_O = 5$ mA to 350 mA			60			60		
Temperature coefficient of output voltage	$I_O = 5$ mA	-55°C to 150°C			-2.4				mV/°C
		0°C to 125°C				-0.6			
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C		200	640		200		μ V
Dropout voltage		25°C		1.1	2.3		1.1		V
Bias current		25°C		1	2		1	2	mA
Bias current change	$V_I = -10.5$ V to -25 V	-55°C to 150°C			0.4				mA
		0°C to 125°C						0.4	
	$I_O = 5$ mA to 350 mA	-55°C to 150°C			0.4				
		0°C to 125°C						0.4	
Short-circuit output current	$V_I = -30$ V	25°C			600		140		mA
Peak output current		25°C	0.5	0.65	1.4		0.65		A

† All characteristics are measured with a 2- μ F capacitor across the input and a 1- μ F capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPES μ A79M12M, μ A79M12C **NEGATIVE-VOLTAGE REGULATORS**

μ A79M12M, μ A79M12C electrical characteristics at specified virtual junction temperature,
 $V_I = -19$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A79M12M			μ A79M12C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage		25°C	-11.5	-12	-12.5	-11.5	-12	-12.5	V
		-55°C to 150°C	-11.4		-12.6				
	$I_O = 5$ mA to 350 mA, $V_I = -14.5$ V to -30 V	0°C to 125°C				-11.4		-12.6	
Input regulation	$V_I = -14.5$ V to -30 V	25°C		9	80		9	80	mV
	$V_I = -15$ V to -25 V			5	50		5	50	
Ripple rejection	$V_I = -15$ V to -25 V, $f = 120$ Hz	$I_O = 100$ mA	-55°C to 150°C			50			dB
			0°C to 125°C				50		
		$I_O = 300$ mA	25°C			54	60	54 60	
Output regulation	$I_O = 5$ mA to 500 mA	25°C		65	240		65	240	mV
	$I_O = 5$ mA to 350 mA			45			45		
Temperature coefficient of output voltage	$I_O = 5$ mA	-55°C to 150°C			-3.6				mV/°C
		0°C to 125°C					-0.8		
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C		300	960		300		μV
Dropout voltage		25°C		1.1	2.3		1.1		V
Bias current		25°C		1.5	3		1.5	3	mA
Bias current change	$V_I = -14.5$ V to -30 V	-55°C to 150°C			0.4				mA
		0°C to 125°C					0.4		
	$I_O = 5$ mA to 350 mA	-55°C to 150°C			0.4				
		0°C to 125°C					0.4		
Short-circuit output current	$V_I = -30$ V	25°C			600		140		mA
Peak output current		25°C	0.5	0.65	1.4		0.65		A

† All characteristics are measured with a 2-μF capacitor across the input and a 1-μF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w < 10$ ms, duty cycle $< 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPES μ A79M15M, μ A79M15C NEGATIVE-VOLTAGE REGULATORS

μ A79M15M, μ A79M15C electrical characteristics at specified virtual junction temperature,
 $V_I = -23$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μA79M15M			μA79M15C			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
Output voltage			25°C	-14.4	-15	-15.6	-14.4	-15	-15.6	V
	I _O = 5 mA to 350 mA, V _I = -17.5 V to -30 V	-55°C to 150°C	-14.25		-15.75					
		0°C to 125°C				-14.25		-15.75		
Input regulation	V _I = -17.5 V to -30 V		25°C	9	80		9	80	mV	
	V _I = -18 V to -28 V			7	50		7	50		
Ripple rejection	V _I = -18.5 V to -28.5 V, f = 120 Hz	I _O = 100 mA	-55°C to 150°C	50					dB	
			0°C to 125°C			50				
		I _O = 300 mA	25°C	54	59		54	59		
Output regulation	I _O = 5 mA to 500 mA		25°C	65	240		65	240	mV	
	I _O = 5 mA to 350 mA			45			45			
Temperature coefficient of output voltage	I _O = 5 mA		-55°C to 150°C	-4.5						mV/°C
			0°C to 125°C				-1			
Output noise voltage	f = 10 Hz to 100 kHz		25°C	375	1200		375		μV	
Dropout voltage			25°C	1.1	2.3		1.1		V	
Bias current			25°C	1.5	3		1.5	3	mA	
Bias current change	V _I = -17.5 V to -30 V	-55°C to 150°C	0.4						mA	
		0°C to 125°C				0.4				
	I _O = 5 mA to 350 mA	-65°C to 150°C	0.4							
		0°C to 125°C				0.4				
Short-circuit output current	V _I = -30 V		25°C	600			140			mA
Peak output current			25°C	0.5	0.65		0.65		A	

† All characteristics are measured with a 2-μF capacitor across the input and a 1-μF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w < 10$ ms, duty cycle $< 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

TYPE μ A79M20C NEGATIVE-VOLTAGE REGULATORS

μ A79M20C electrical characteristics at specified virtual junction temperature
 $V_I = -29$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		μ A79M20C			UNIT
			MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 350 mA, $V_I = -23$ V to -35 V	25°C	-19.2	-20	-20.8	V
		0°C to 125°C	-19		-21	
Input regulation	$V_I = -23$ V to -35 V	25°C		12	80	mV
	$V_I = -24$ V to -34 V			10	70	
Ripple rejection	$V_I = -24$ V to -34 V, $f = 120$ Hz	0°C to 125°C	50			dB
	$I_O = 100$ mA $I_O = 300$ mA	25°C	54	58		
Output regulation	$I_O = 5$ mA to 500 mA	25°C		75	300	mV
	$I_O = 5$ mA to 350 mA			50		
Temperature coefficient of output voltage	$I_O = 5$ mA	0°C to 125°C		-1		mV/°C
Output noise voltage	$f = 10$ Hz to 100 kHz	25°C		500		μ V
Dropout voltage		25°C		1.1		V
Bias current		25°C		1.5	3.5	mA
Bias current change	$V_I = -23$ V to -35 V	0°C to 125°C			0.4	mA
	$I_O = 5$ mA to 350 mA				0.4	
Short-circuit output current	$V_I = -30$ V	25°C		140		mA
Peak output current		25°C		650		A

†All characteristics are measured with a 2- μ F capacitor across the input and a 1- μ F capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w < 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPE μ A79M24C

NEGATIVE-VOLTAGE REGULATORS

μ A79M24C electrical characteristics at specified virtual junction temperature,
 $V_I = -33$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	μ A79M24C			UNIT
		MIN	TYP	MAX	
Output voltage	$I_O = 5$ mA to 350 mA, $V_I = -27$ V to -38 V	25° C	-23	-24	V
		0° C to 125° C	-22.8	-25.2	
Input regulation	$V_I = -27$ V to -38 V	25° C	12	80	mV
	$V_I = -28$ V to -38 V		12	70	
Ripple rejection	$V_I = -28$ V to -38 V, $I_O = 100$ mA	0° C to 125° C	50		dB
	$f = 120$ Hz, $I_O = 300$ mA	25° C	54	58	
Output regulation	$I_O = 5$ mA to 500 mA	25° C	75	300	mV
	$I_O = 5$ mA to 350 mA		50		
Temperature coefficient of output voltage	$I_O = 5$ mA	0° C to 125° C	-1		mV/°C
Output noise voltage	$f = 10$ Hz to 100 kHz	25° C	600		μ V
Dropout voltage		25° C	1.1		V
Bias current		25° C	1.5	3.5	mA
Bias current change	$V_I = -27$ V to -38 V	0° C to 125° C		0.4	mA
	$I_O = 5$ mA to 350 mA			0.4	
Short-circuit output current	$V_I = -30$ V	25° C	140		mA
Peak output current		25° C	850		A

† All characteristics are measured with a 2- μ F capacitor across the input and a 1- μ F capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w < 10$ ms, duty cycle $< 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

SERIES μ A79M00
NEGATIVE-VOLTAGE REGULATORS

THERMAL INFORMATION

KC PACKAGE
FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

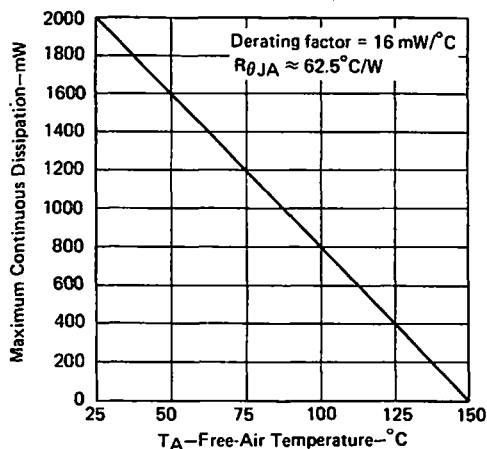


FIGURE 1

KC PACKAGE
CASE TEMPERATURE
DISSIPATION DERATING CURVE

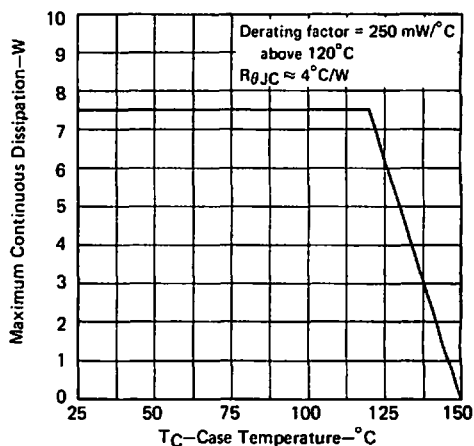


FIGURE 2

JG PACKAGE
FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

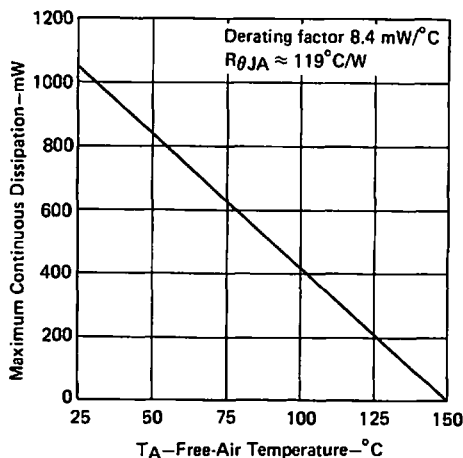


FIGURE 3

Appendix

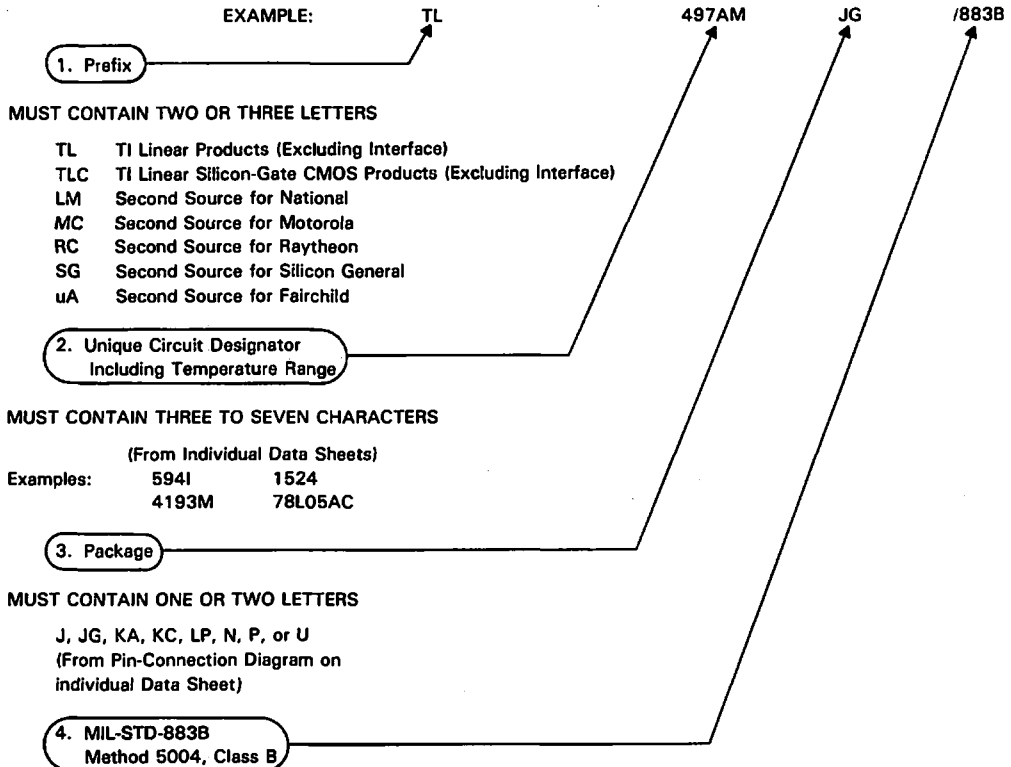
**Ordering Instructions
Mechanical Data**

3

ORDERING INSTRUCTIONS

Electrical characteristics presented in this data book, unless otherwise noted, apply for the circuit type(s) listed in the page heading regardless of package. The availability of a circuit function in a particular package is denoted by an alphabetical reference above the pin-connection diagram(s). These alphabetical references refer to mechanical outline drawings shown in this section.

Factory orders for circuits described in this data book should include a four-part type number as explained in the following example.



OMIT /883B WHEN NOT APPLICABLE

Circuits are shipped in one of the carriers below. Unless a specific method of shipment is specified by the customer (with possible additional costs), circuits will be shipped on the most practical carrier.

Flat (U)

- Barnes Carrier
- Milton Ross Carrier

Dual-In-Line (J, JG, N, P)

- Slide Magazines
- A-Channel Plastic Tubing
- Barnes Carrier
- Sectioned Cardboard Box
- Individual Plastic Box

Plug-In (LP)

- Barnes Carrier
- Sectional Cardboard Box
- Individual Cardboard Box

TO-3 (KA)

- Form Pack

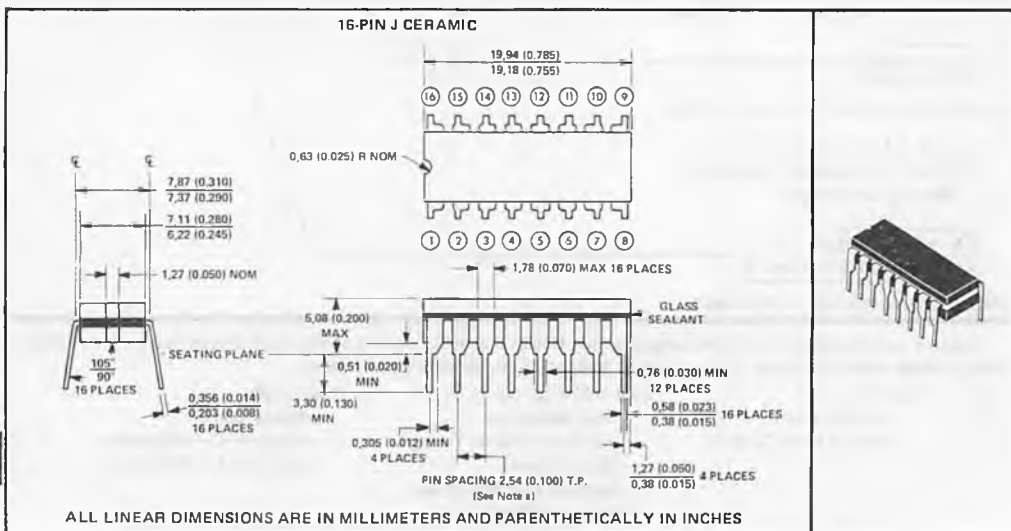
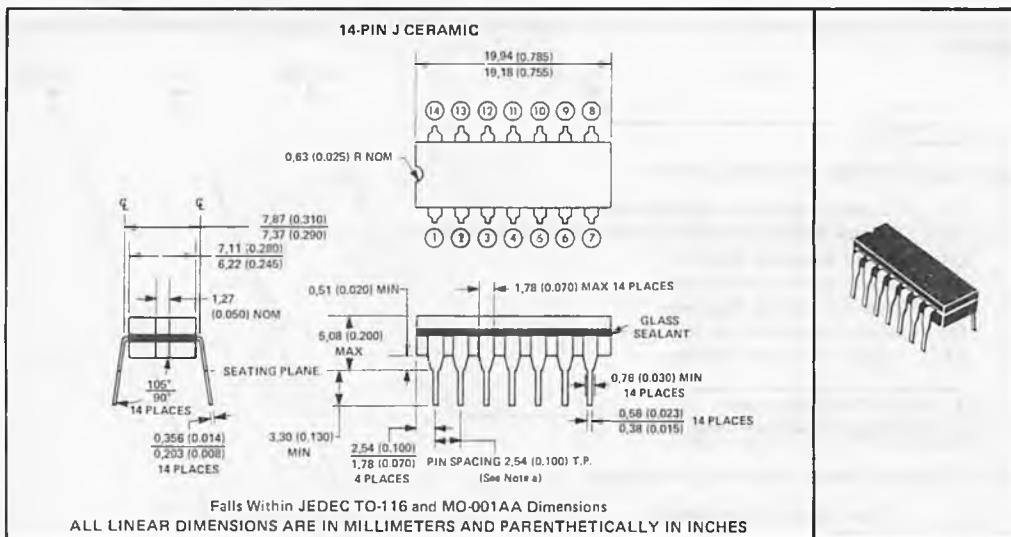
TO-220AB (KC)

- Bulk Pack
- Sleeves

VOLTAGE REGULATOR CIRCUITS MECHANICAL DATA

J ceramic dual-in-line packages

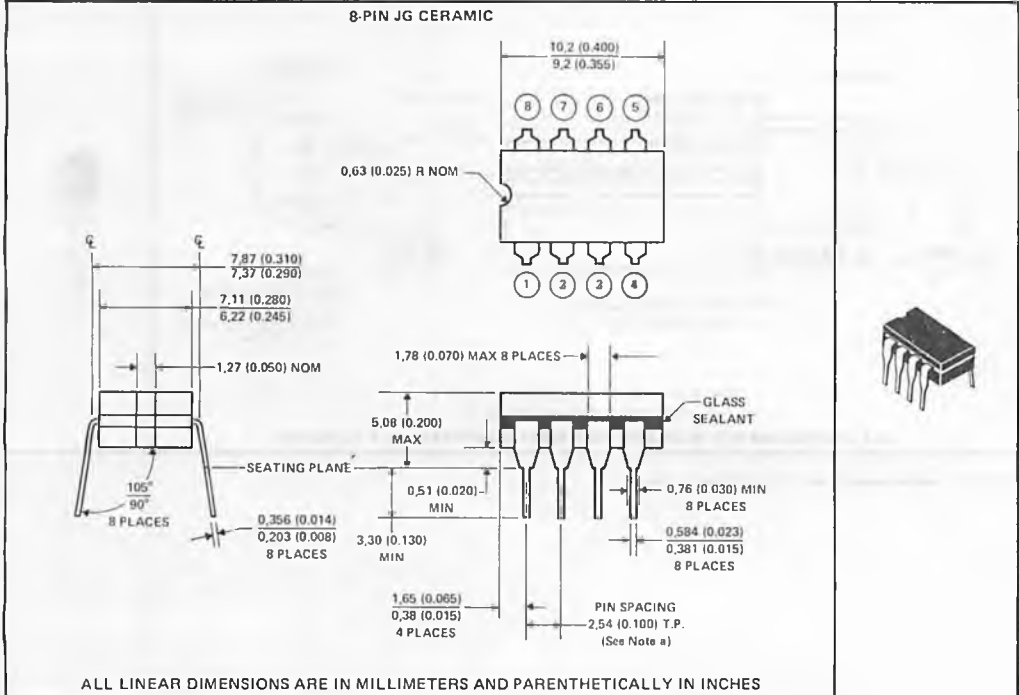
These hermetically sealed dual-in-line packages consist of a ceramic base, ceramic cap, and a 14- or 16-lead frame. Hermetic sealing is accomplished with glass. The packages are intended for insertion in mounting-hole rows on 7,62 (0.300) centers (see Note a). Once the leads are compressed and inserted, sufficient tension is provided to secure the package in the board during soldering.



NOTE a: Each pin centerline is located within 0.25 (0.010) of its true longitudinal position.

JG ceramic dual-in-line package

This hermetically sealed dual-in-line package consists of a ceramic base, ceramic cap, and 8-lead frame. The package is intended for insertion in mounting-hole rows 7,62 (0.300) centers (see Note a). Once the leads are compressed and inserted, sufficient tension is provided to secure the package in the board during soldering.



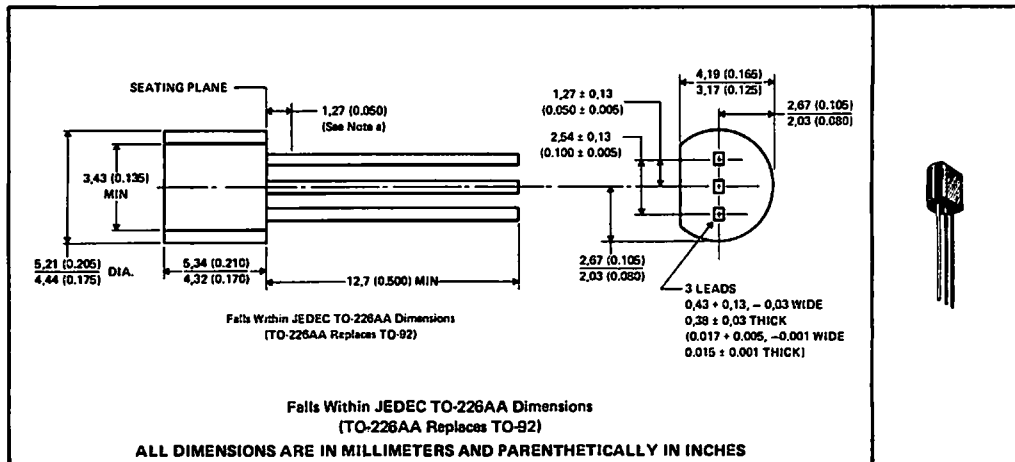
NOTE a. Each pin centerline is located within 0.25 (0.010) of its true longitudinal position.

VOLTAGE REGULATOR CIRCUITS

MECHANICAL DATA

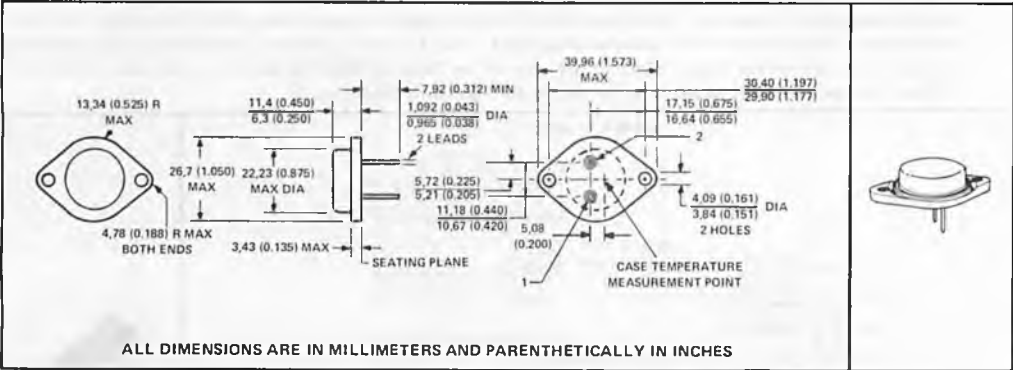
LP plastic package

This package is an encapsulation in a plastic compound specifically designed for this purposes. The package will withstand withstand soldering temperatures without deformation. The package exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B.

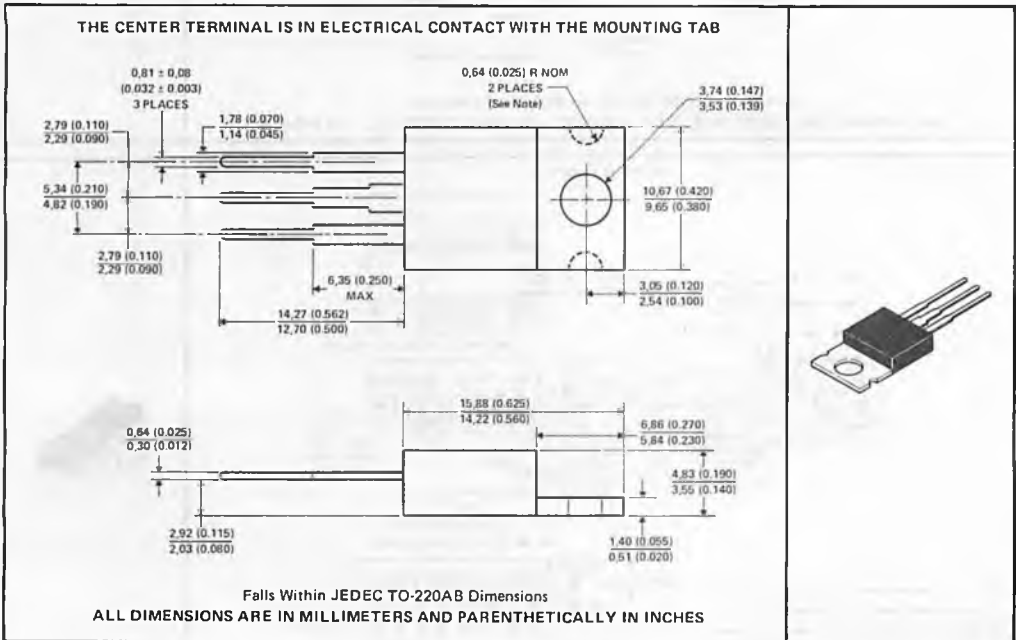


NOTE a: Lead dimensions are not controlled in this area.

KA (TO-3) package



KC (TO-220AB) package

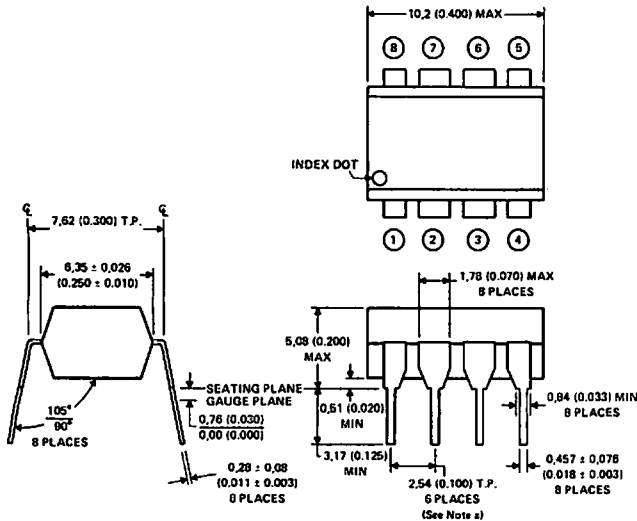


NOTE: Notches may or may not be present.

P dual-in-line plastic package

This dual-in-line package consists of a circuit mounted on an 8-lead frame and encapsulated in an electrically nonconductive plastic compound. The compound will withstand soldering temperature with no deformation and circuit performance characteristics remain stable when operated under high-humidity conditions. This package is intended for insertion in mounting hole rows on 7,62 (0.300) centers. Once the leads are compressed and inserted, sufficient tension is provided to secure the package in the board during soldering.

8-PIN P PLASTIC



ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

NOTE A: Each pin centerline is within 0,13 (0.005) radius of true position at the gauge plane with maximum material condition and unit installed.



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